USAARL Report No. 91-21

AD-A243 174

The Effect of Impulse Presentation Order on Hearing Trauma in the Chinchilla

By

James H. Patterson, Jr.
Dennis L. Curd
Ilia Lomba Gautier

Sensory Research Division

and

Roger P. Hamernik
William A. Ahroon
George A. Turrentine
C. E. Hargett, Jr.

Auditory Research Laboratory
State University of New York at Plattsburgh

September 1991

Approved for public release; distribution unlimited.

91-16807

91 11 29 058

United States Army Aeromedical Research Laboratory
Fort Rucker, Alabama 36362-5292

Notice

Qualified requesters

Qualified requesters may obtain copies from the Defense Technical Information Center (DTIC), Cameron Station, Alexandria, Virginia 22314. Orders will be expedited if placed through the librarian or other person designated to request documents from DTIC.

Change of address

Organizations receiving reports from the U.S. Army Aeromedical Research Laboratory on automatic mailing lists should confirm correct address when corresponding about laboratory reports.

Disposition

Destroy this report when it is no longer needed. Do not return it to the originator.

Disclaimer

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other official documentation. Citation of trade names in this report does not constitute an official Department of the Army endorsement or approval of the use of such commercial items.

Animal use

In conducting the research described in this report, the investigators adhered to the Guide for care and use of laboratory animals, as promulgated by the Committee on Care and Use of Laboratory Animals of the Institute of Laboratory Resources Commission on Life Sciences, National Academy of Sciences-National Research Council.

Reviewed:

THOMAS L. FREZELL
LTC, MS
Director, Sensory Research Division

ROGER W. WILEY
Chairman, Scientific Review Committee

Released for publication:

DAVID H. KARNEY
Colonel, MC, SFS
Commanding

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION
UNCLASSIFIED

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

2b. DECLASSIFICATION / DOWNGRADING SCHEDULE

3. DISTRIBUTION / AVAILABILITY OF REPORT
Approved for public release; distribution unlimited

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
USAARL Report No. 91-21

5. MONITORING ORGANIZATION REPORT NUMBER(S)
U.S. Army Medical Research and Development Command

6a. NAME OF PERFORMING ORGANIZATION
Sensory Research Division
U.S. Army Aeromed Rsch Lab

6b. OFFICE SYMBOL (If applicable)
SGRD-UAS-AS

7a. NAME OF MONITORING ORGANIZATION

6c. ADDRESS (City, State, and ZIP Code)
P.O. Box 577
Fort Rucker, AL 36362-5292

7b. ADDRESS (City, State, and ZIP Code)
Fort Detrick
Frederick, MD 21701-5012

8a. NAME OF FUNDING / SPONSORING ORGANIZATION

8b. OFFICE SYMBOL (If applicable)

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
Partial effort under contract #DAMD17-86-C-6139

8c. ADDRESS (City, State, and ZIP Code)

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
62777A	3E162777A878		157
0601102	3M161102BS15		282

11. TITLE (Include Security Classification)
The effect of impulse presentation order on hearing trauma in the chinchilla

12. PERSONAL AUTHOR(S) James H. Patterson, Jr., Dennis L. Curd, Ilia Lomba Gautier, Roger P. Hamernik, William A. Ahroon, George A. Turrentine, and C.E. Hargett, Jr.

13a. TYPE OF REPORT

13b. TIME COVERED FROM ______ TO ______

14. DATE OF REPORT (Year, Month, Day)
1991 September

15. PAGE COUNT
58

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP
20	01	

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Impulse noise, hearing, chinchilla, audiometry

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Existing criteria for exposure to impulse noise do not provide any explicit means for evaluating exposures for which the peak SPL of the impulses varies in any given exposure day. Approaches to evaluating such exposures have included the application of a "proportional dose" method such as used with continuous noise or the use of an average level. Implicit in these approaches is the assumption that the order in which a sequence of variable intensity impulses is presented is not important. This same assumption is also implicit in any energy-based exposure criteria. This report presents the results of a pilot experiment designed to test the validity of this assumption. Two groups of chinchillas were exposed to a sequence of 100 impulses. One group received 90 exposures at 138-dB peak SPL impulses followed by 10 exposures at 146-dB peak SPL impulses; the second group received the same series of impulses but in reverse order. The results from these two groups were compared to the results of 100 exposures at 147-dB peak SPL impulses from a report by Patterson et al., (1986). CONTINUED ON BACK

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT
☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION

22a. NAME OF RESPONSIBLE INDIVIDUAL
Chief, Scientific Information Center

22b. TELEPHONE (Include Area Code)
(205) 255-6907

22c. OFFICE SYMBOL
SGRD-UAX-SI

DD Form 1473, JUN 86 — Previous editions are obsolete. — SECURITY CLASSIFICATION OF THIS PAGE

19. ABSTRACT CONTINUED

The 139-dB peak SPL exposure had the same total energy as the two variable intensity exposures. The results of the three equivalent energy exposures showed that exposures having equal energies could produce statistically different levels of hearing trauma. However, while the mean data were very suggestive in showing an effect of the presentation order, this result did not hold up to statistical analysis because of a large intersubject variability.

Acknowledgment

This research was partially completed with the Auditory Research Laboratory, State University of New York at Plattsburgh, under Contract #DAMD17-86-C-6139, dated 3 February 1986.

This page intentionally left blank.

Table of contents

List of figures

List of tables

Introduction

The Committee on Hearing, Bioacoustics and Biomechanics (CHABA) of the National Academy of Sciences (1968), issued its "Proposed damage risk criterion for impulse noise (gunfire)." This criterion defines an acceptable exposure for 100 impulses per day and provides a trading rule which allows the derivation of exposure limits for exposures other than 100 impulses per day. There is an implicit assumption in this approach that the intensity of all the impulses is the same. There is no explicit procedure for estimating the hazard when a daily exposure consists of impulses whose peak sound pressure level (SPL) varies during the course of the day. The CHABA document has served as the basis for our current military exposure limits, MIL-STD-1474(C) (1979). This military document has no explicit way of treating exposures to different intensities within the same day. Analogous with the procedures used to evaluate steady state noise exposures, the U.S. Army has adopted a "proportional dose" procedure. For each intensity, an allowable number of rounds is calculated. An exposure is considered acceptable, if the sum of the fractions resulting from dividing the actual number of rounds by the allowable number of rounds is less than one.

Unpublished data collected during the developmental testing of some weapons shows a bimodal distribution of intensities in which about 10 percent of the rounds are 8 to 10 dB higher than the others. There have been suggestions made that the hazard of these weapons should be estimated by computing an average level. There is no data available from exposures to variable intensities to support such an approach. Other approaches to the evaluation of variable intensity exposures can be based upon equal energy considerations. However, if one accepts that an equal energy based measure of an impulse noise exposure can be related directly to the hazards associated with that exposure, then the order in which a series of higher and lower peak SPL impulses is presented should not be important in the final trauma to the auditory system.

The study reported here was undertaken to provide an initial set of data relevant to some of the above issues. Specifically, two groups of chinchillas were exposed to 100 impulses. One group was subjected to 90 exposures, 139-dB peak SPL impulses followed by 10 more at 146-dB SPL. The second group was given the same exposure but in the reverse order. The effect of these two equal energy exposure conditions on the auditory system was evaluated in terms of threshold shift (TS), permanent threshold shift (PTS) and sensory cell loss.

Methods and procedures

The methods and experimental paradigm were identical to those presented in Patterson et al., (1986) and thus will not be repeated in detail here. Basically, an avoidance conditioning paradigm was used to obtain pre- and postexposure threshold measurements at 10 audiometric test frequencies between 0.125 and 8 kHz. Thresholds were followed after exposure at regular intervals over a period of 30 days, at which time the animals were euthanatized for surface preparation histology. Each animal was individually exposed at a normal angle of incidence to one of the two exposure conditions identified as H/L or L/H in Table 1. The exposures consisted of the presentation of 100 impulses at the rate of one per 3 seconds. Each experimental group consisted of six animals. The impulses were presented to two different groups of animals in two different orders. The first group was exposed to 90 impulses with a 138-dB peak SPL followed by 10 impulses with a 146-dB peak SPL, the L/H group. The second group received the 10 at 146-dB peak SPL impulses first, followed by the 90 at 138-dB peak SPL, the H/L group. Comparison between these two exposures conditions will be made in terms of the amount of threshold shift, permanent threshold shift, and sensory cell loss produced. Upper and lower bounds for the expected TS, PTS, and cell loss were established using the results from Patterson et al., (1986) where animals were exposed to 100 similar impulses but at 147-dB peak SPL (Reference group I) or 139-dB peak SPL (Reference group II). A comparison of the various energies of the exposure conditions from the Patterson et al., (1986) reference conditions, as well as, the H/L and L/H exposure conditions is presented in Table 1. All the impulses were similar in the pressure-time (p-t) plane. The impulses were computer generated (Patterson et al., 1986). The p-t history and energy spectra of the type of impulse used is shown in Figure 1. From the pressure-time history of the impulsive stimulus, the integral of pressure squared over time shown in Table 1 was computed to obtain the total sound exposure level (SEL) re: 20 Pa sec for each exposure condition (Young, 1970).

Results and discussion

The mean preexposure audiogram for the 12 animals used in these experiments along with the normative data of Miller (1970) is shown in Figure 2. The group mean thresholds for the two groups are shown in Table 2. A two-way analysis of variance showed that there was no statistically significant difference in the preexposure thresholds between the two groups ($F = 0.32$, $df = 1/10$), nor was there a statistically significant interaction between the main effects of group and frequency ($F = 1.50$, $df = 9/90$, $p < .05$) which was expected given our knowledge of the chinchilla audiogram (Fay, 1988). For each animal, threshold shifts were computed by subtracting that animal's preexposure threshold from the postexposure threshold at each audiometric test frequency. The audiometric and histological effects of each exposure were documented as follows:

(1) The mean threshold shift recovery functions over a 30-day period for each group and each test frequency (Figures 3 through 12).

(2) The maximum TS (TS_{max}) for each group and for each test frequency (Figure 13).

(3) The permanent threshold shift (PTS) for each group and for each test frequency (Figure 14).

(4) The group mean outer and inner hair cell loss (OHC and IHC) within octave band lengths of the basilar membrane at the indicated frequencies (Figure 15).

In Figures 3 through 15, bars represent the standard error of the mean. If no bar is present, the standard error was less than the size of the symbol. All the individual animal data and group mean data summaries can be found in the Appendix.

From the mean recovery curves shown in Figures 3 through 12, the general impression is that the low peak followed by the high peak sequence of impulses (L/H) produced the greater threshold shift over the entire 30-day recovery period. For the most part, the two sets of recovery functions for groups L/H and H/L are approximately parallel to each other over the 30-day course of recovery. A statistical analysis of the recovery functions was not performed to establish whether or not the apparent differences in the recovery functions are in fact statistically significant. Instead, attention will be focused on the TS_{max} variable which is a good index of the acute effect of an exposure (Hamernik et al., 1988), and on the permanent effects quantified by PTS and sensory cell loss.

The experiment was designed to probe at two issues; (1) to what extent do equal energy exposure conditions produce equivalent changes in the independent variables? and (2) to what extent does the order of impulse presentation (which does not affect the total energy of an exposure) affect the dependent variables? A graphical comparison among the experimental groups for the mean TS_{max}, PTS and sensory cell loss variables is shown in Figures 13, 14, and 15 respectively. The number of impulses and the peak levels in the L/H and H/L groups were chosen so that the mean peak level and the total

SEL would be approximately the same as the Reference II group. Thus, the Reference II group would serve as another equivalent energy exposure condition and as a lower bound to what would be expected from the L/H and H/L group. The Reference I exposure condition with 7 dB greater total energy serves as an upper bound for the expected trauma.

The data in Figures 13 to 15 was first subjected to a two-way analyses of variance with repeated measures on one factor (frequency). Each analysis included the L/H, H/L, and Ref. II groups (The 2.8 kHz test frequency was not collected in the Patterson et al., (1986) study and therefore was excluded from this analysis). The summary table for this analysis is presented in Table 3. The main effect of exposure was not statistically significant for any of the four analyses. However, the interaction of exposure and frequency was significant for both audiometric measures (TS_{max}): $F = 1.87$, $df = 16/120$, $p < .05$; PTS: $F = 2.04$, $df = 16/120$, $p < .05$), indicating there was a significant effect of the noise exposure on maximum threshold shift and PTS and that this effect was dependent upon the test frequency at which the dependent variable was measured. The same was not true for the histological variables where neither the main effect of exposure nor the interaction of exposure and frequency was statistically significant. The main effect of frequency was statistically significant for all four analyses indicating the effect of the exposure differed across the audiometric test frequency and place on the basilar membrane. Thus, although the three exposure groups had the same total energy there were frequency specific differences among the dependent variables used to quantify the results of the exposure.

A posthoc analysis of differences in audiometric variables between the L/H and H/L groups in Figures 13 to 15 was performed using the Student-t distribution. There were statistically significant differences between the two groups for both audiometric variables at the 0.125 kHz test frequency (TS_{max}): $t = -2.47$, $df = 10$, $p < .05$; PTS: $t = -2.84$, $df = 10$, $p < .05$). There was also a significant difference in TS_{max}) measured at the 2.8 kHz test frequency ($t = -2.60$, $df = 10$, $p < .05$) and in PTS at the 1.4 kHz test frequency ($t = -2.24$, $df = 10$, $p < .05$). All other analyses among these groups were not statistically significant, although many approached significance at the 0.05 level.

In order to determine if the sequence in which a series of variable intensity impulses is presented is important, two-factor analyses of variance with repeated measures on one factor (frequency) were performed on TS_{max}, PTS, and inner and outer hair cell losses using only the groups L/H and H/L. The results are summarized in Table 4. The main effect of the

Table 1

A listing of the experimental and reference groups and their respective exposure parameters.

Group Identification	Peak (dB SPL)	# of Impulses	Energy (J/m^2)	Total Energy (J/m^2)	Total SEL (dB)
Upper Bound (Ref. I)*	147	100	0.095	9.50	130
Lower bound (Ref. II)*	139	100	0.015	1.50	122
High level (H)	146	10	0.075	0.75	119
Low level (L)	138	90	0.012	1.08	120
High/low level (H/L)	146/138	10/90	-	1.83	123
Low/high level (L/H)	138/146	90/10	-	1.83	123

* Ref. I and Ref. II data are taken from Patterson et al. (1986)

Table 2

Preexposure Threshold Means (dB) and Standard Deviations for all Groups Compared to Published Norms

Group	N	125	250	500	1000	1400	2000	2800	4000	5700	8000	
		Test Frequency (Hz)										
H/L	6	24.1	7.1	0.2	0.7	0.1	2.0	3.1	1.0	1.5	4.0	$\bar{X}$
		2.5	3.2	1.7	2.2	3.4	1.6	3.7	1.8	1.1	3.2	s
L/H	6	24.8	5.3	2.5	1.3	1.0	3.2	0.7	2.5	2.3	5.5	$\bar{X}$
		1.9	3.4	2.1	1.4	3.2	2.1	2.1	2.1	2.6	3.5	s
Total	12	24.5	6.2	1.4	1.0	0.5	2.6	1.9	1.8	1.9	4.8	$\bar{X}$
		2.2	3.3	2.2	1.8	3.2	1.9	3.1	2.0	1.9	3.3	s
Miller		19.9	8.8	5.1	3.0	2.2	2.7	-0.2	1.9	1.9	5.8	$\bar{X}$
(1970)		5.4	3.9	6.1	4.1	6.6	4.7	4.9	7.1	6.7	5.4	s
		36	36	36	36	34	36	35	36	35	36	N

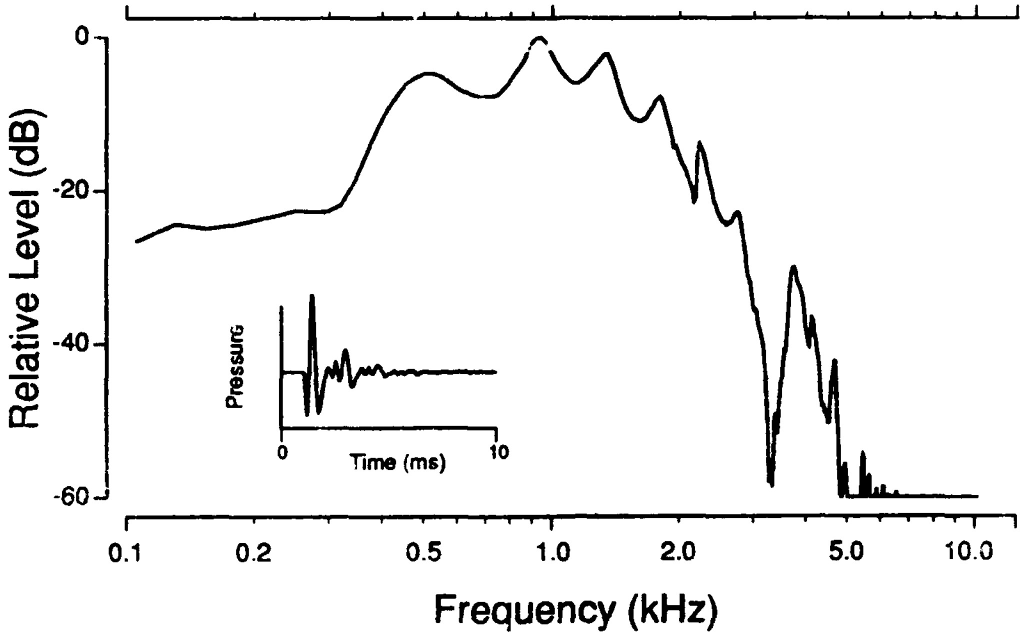


Figure 1. Amplitude spectrum and pressure-time waveform for the 146 dB peak SPL impulse.

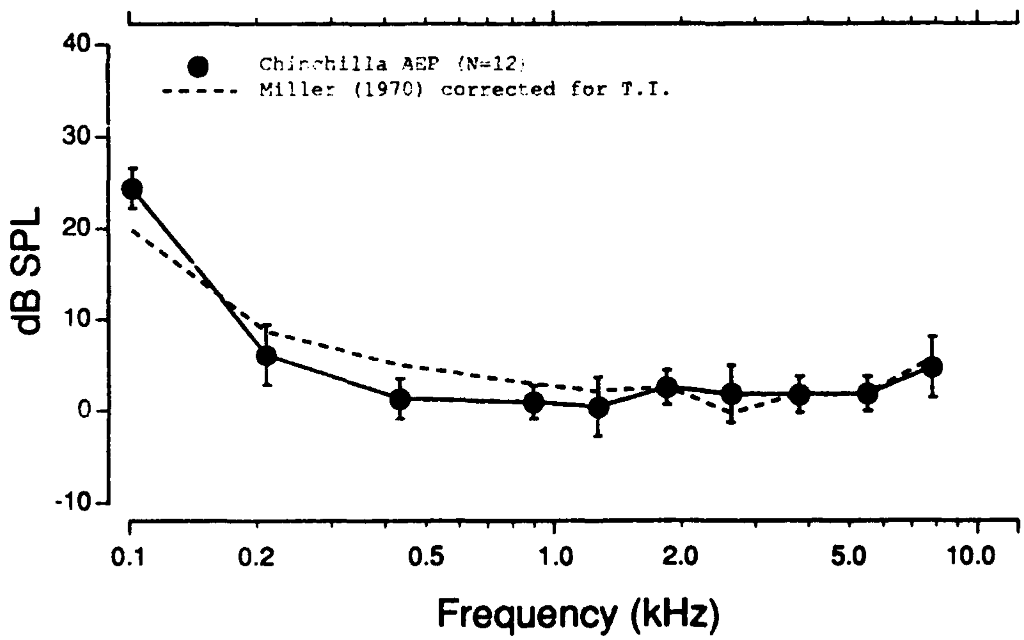


Figure 2. Mean preexposure thresholds for 12 chinchillas.

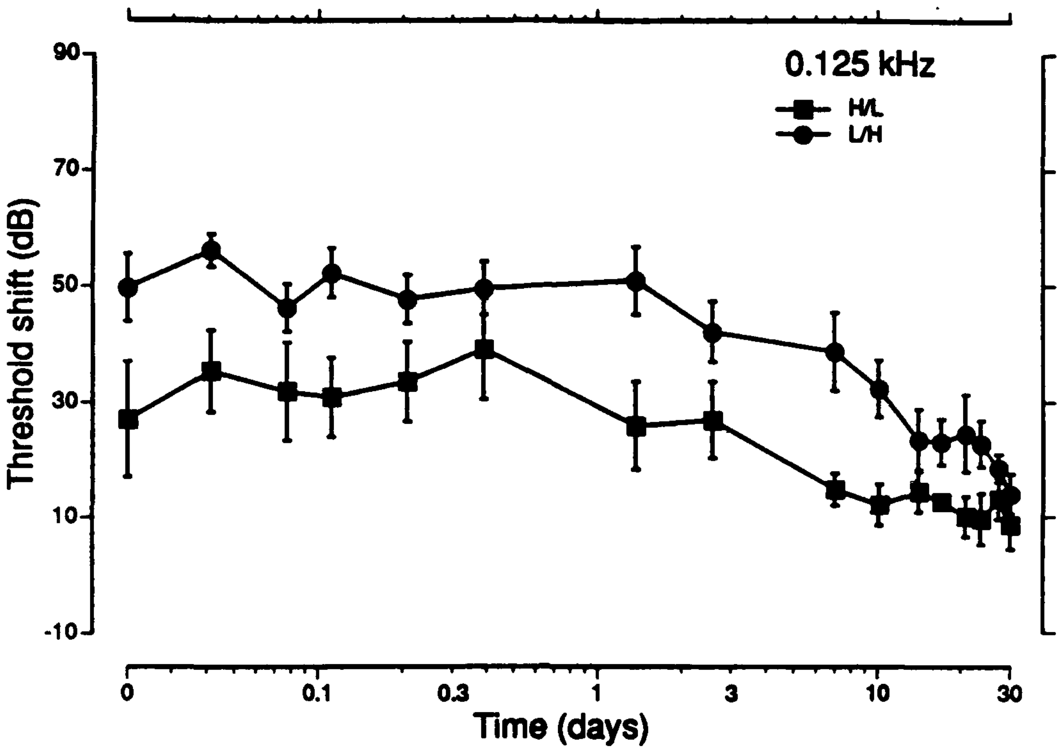


Figure 3. The group mean threshold recovery curves for each exposure condition at the 0.125 kHz test frequency

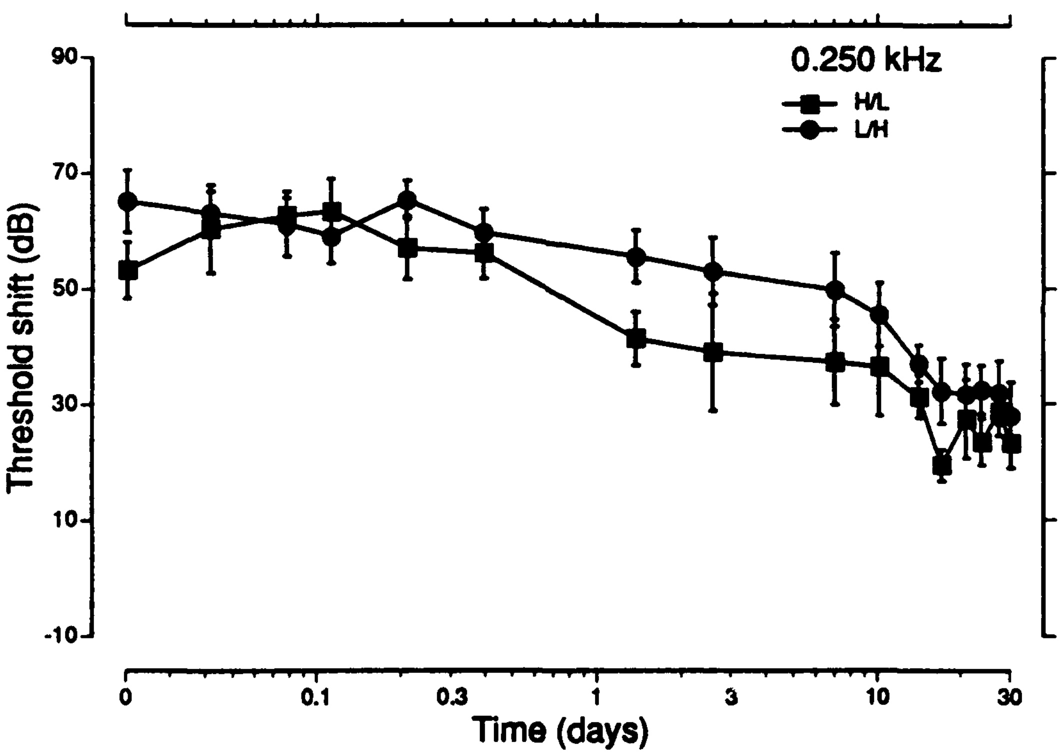


Figure 4. The group mean threshold recovery curves for each exposure condition at the 0.25 kHz test frequency

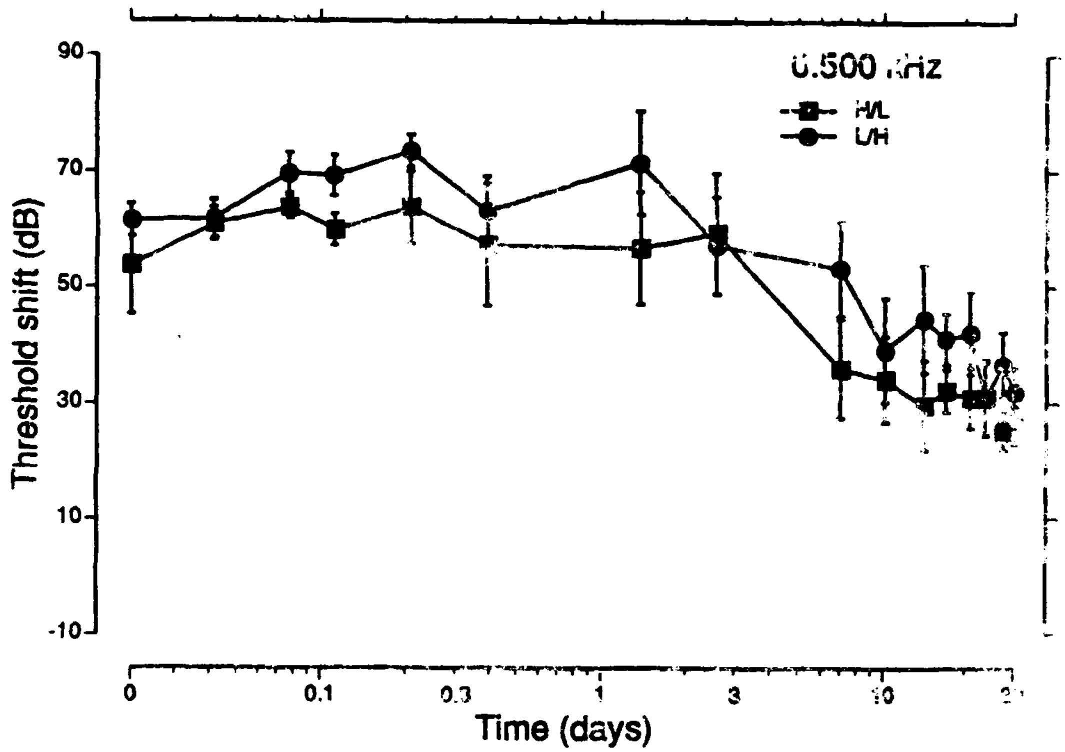


Figure 5. ***The group mean threshold recovery curves for each exposure condition at the 0.5 kHz test frequency***

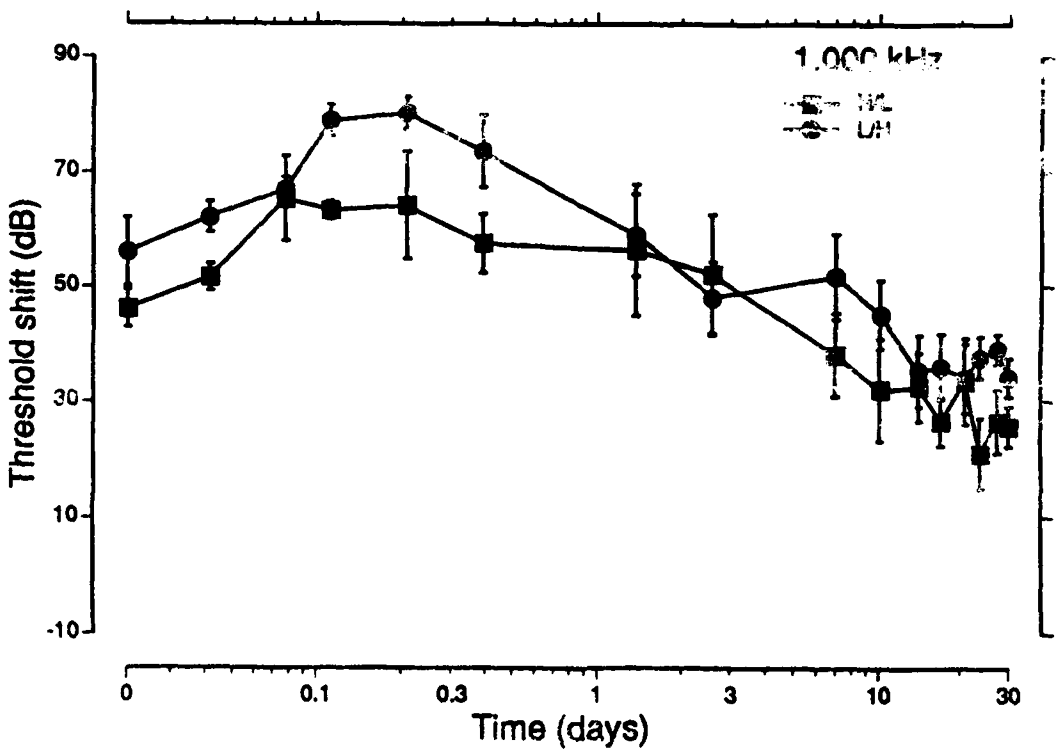


Figure 6. ***The group mean threshold recovery curves for each exposure condition at the 1.0 kHz test frequency***

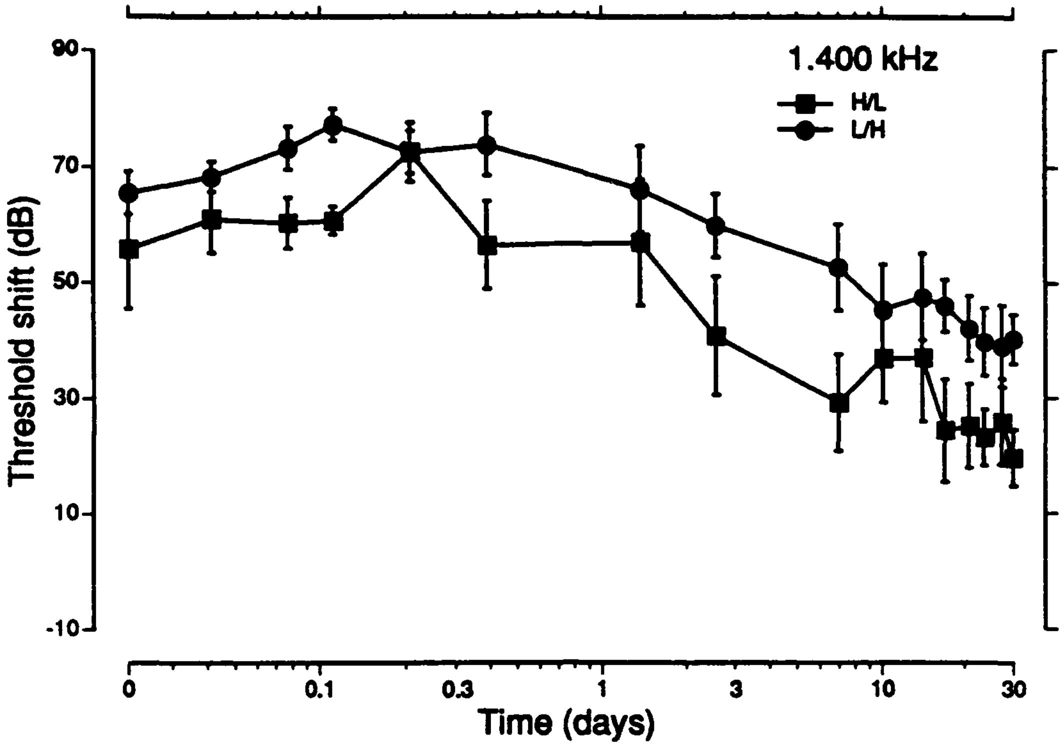


Figure 7. The group mean threshold recovery curves for each exposure condition at the 1.4 kHz test frequency

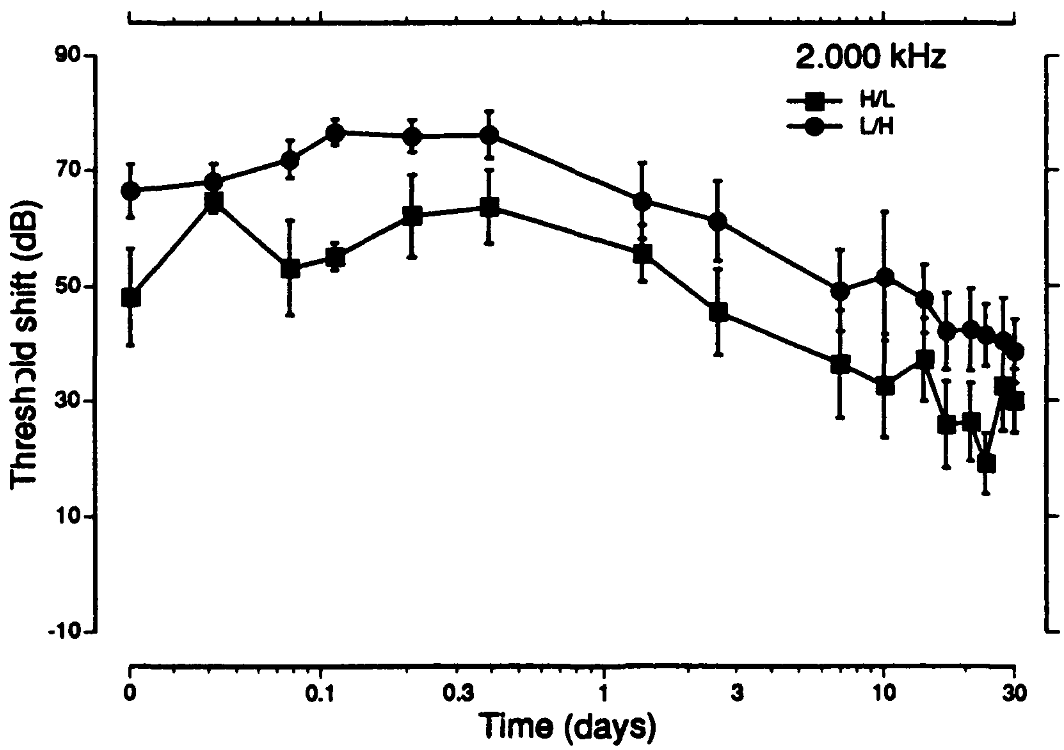


Figure 8. The group mean threshold recovery curves for each exposure condition at the 2.0 kHz test frequency

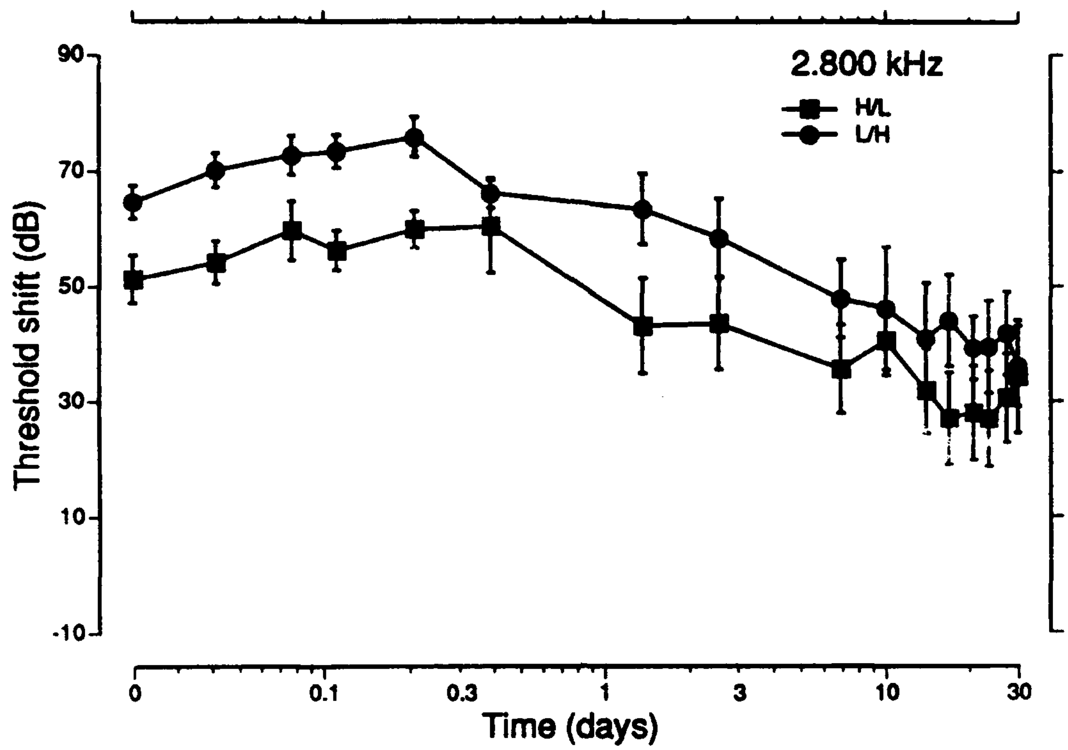


Figure 9. The group mean threshold recovery curves for each exposure condition at the 2.8 kHz test frequency

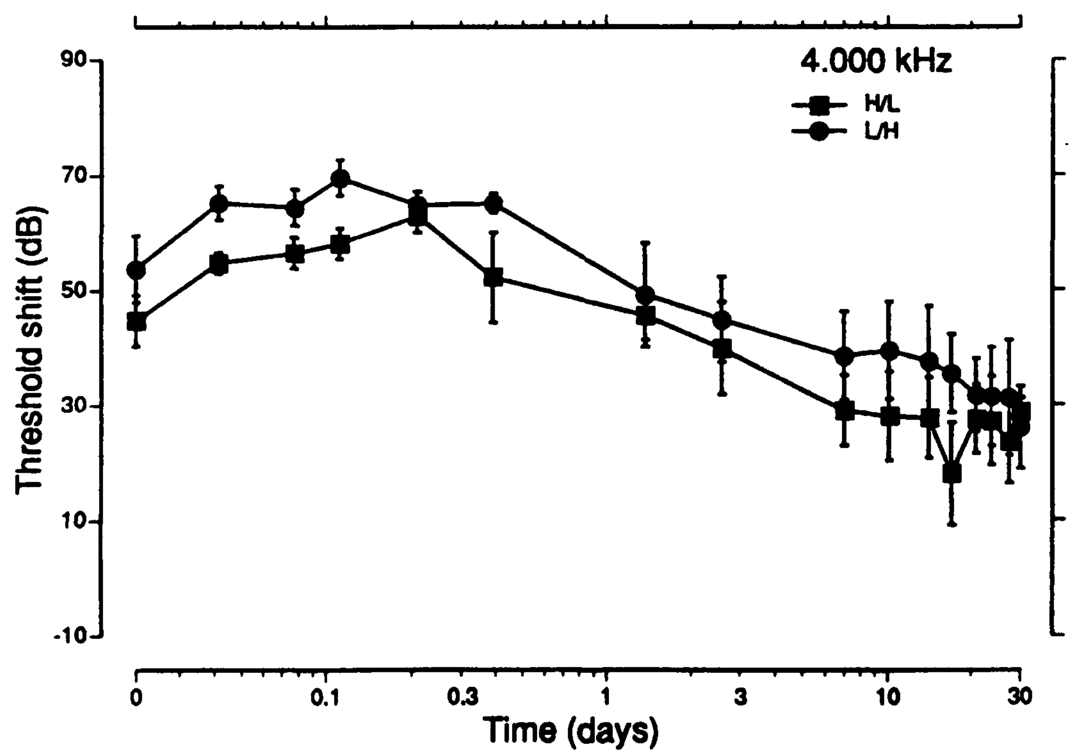


Figure 10. The group mean threshold recovery curves for each exposure condition at the 4.0 kHz test frequency

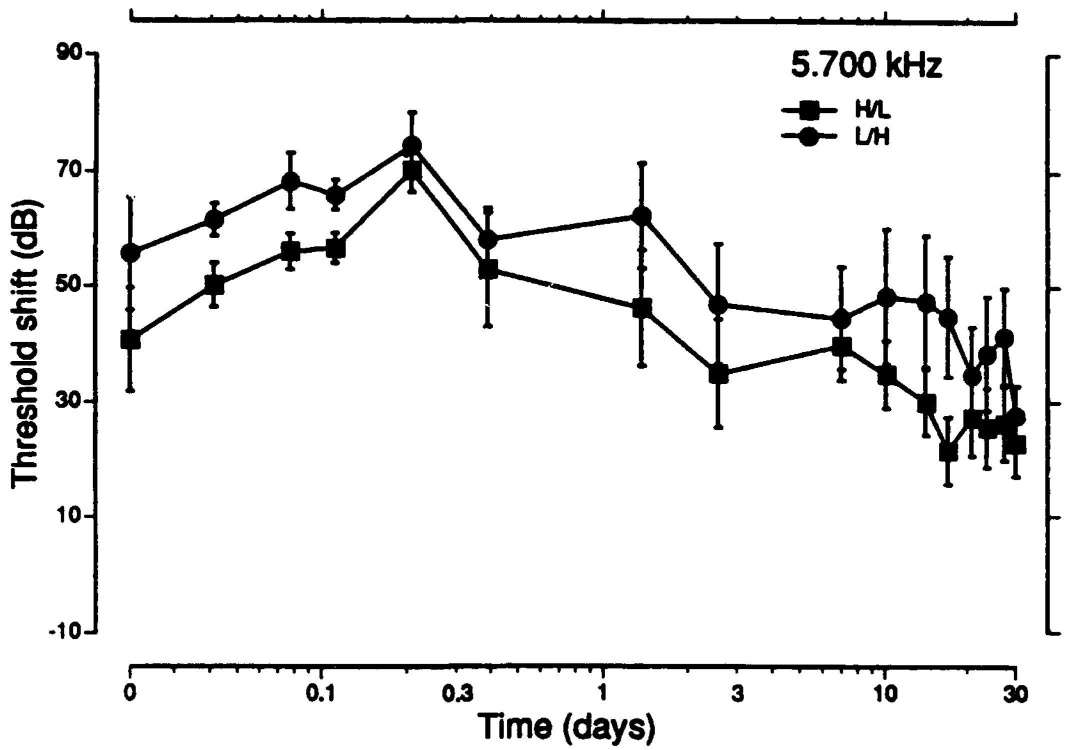


Figure 11. The group mean threshold recovery curves for each exposure condition at the 5.7 kHz test frequency

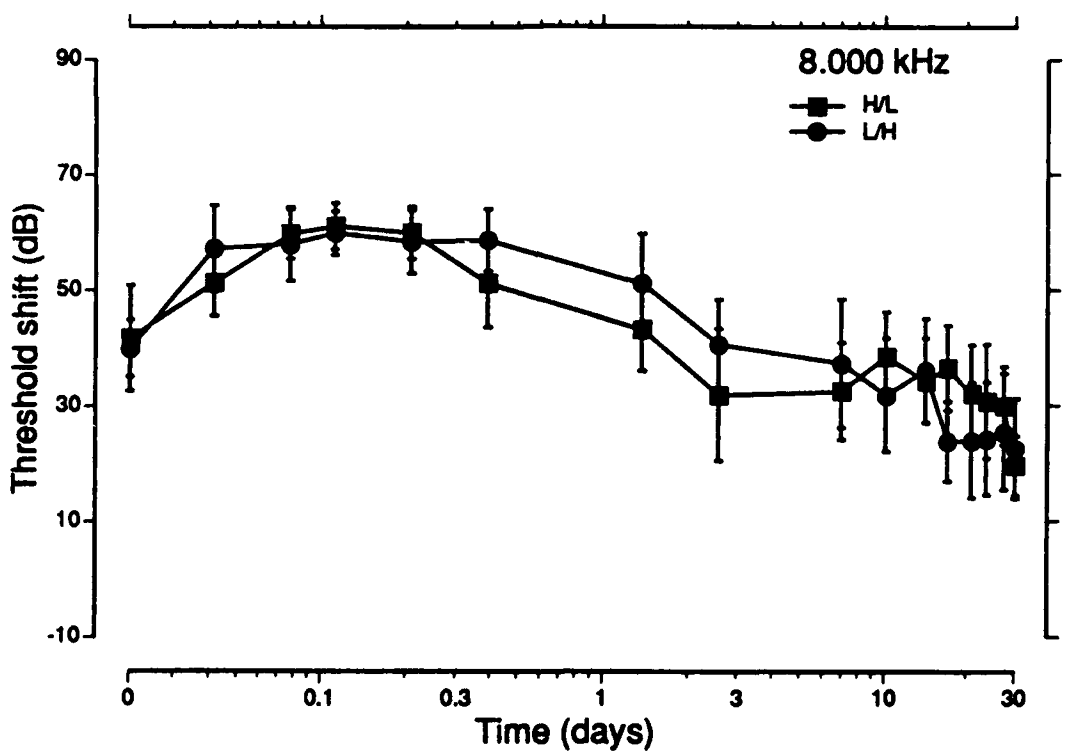


Figure 12. The group mean threshold recovery curves for each exposure condition at the 8.0 kHz test frequency

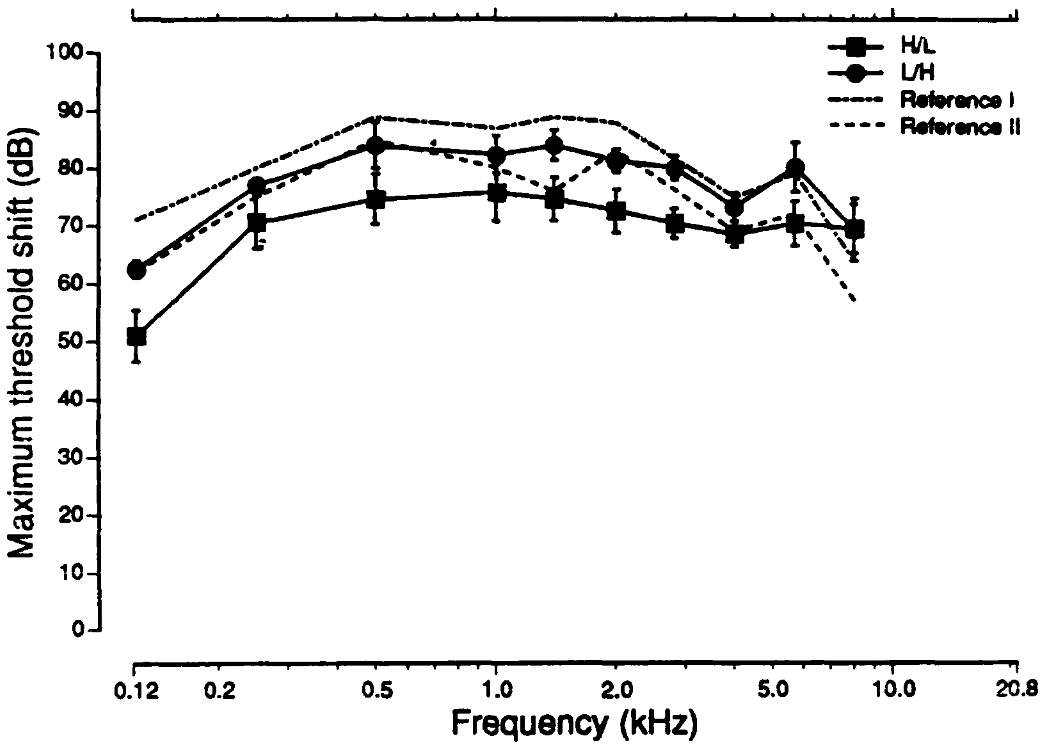


Figure 13. *The postexposure group mean maximum threshold shift (TSmax) for each of the experimental groups at each test frequency*

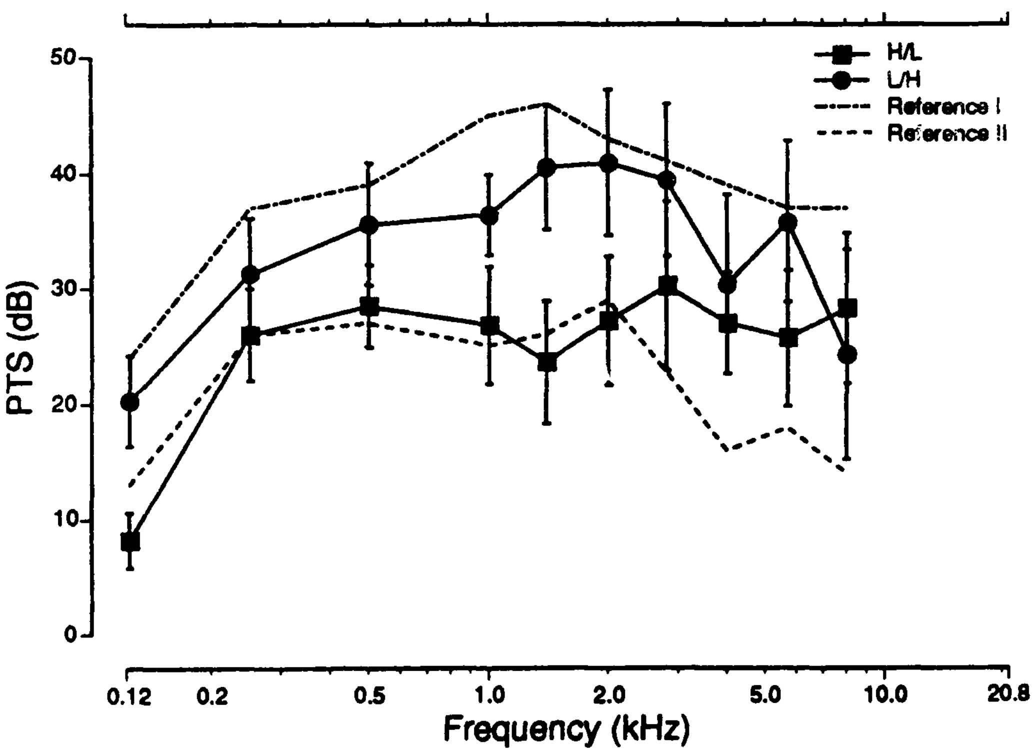


Figure 14. *The group mean permanent threshold shift at each test frequency for each exposure condition*

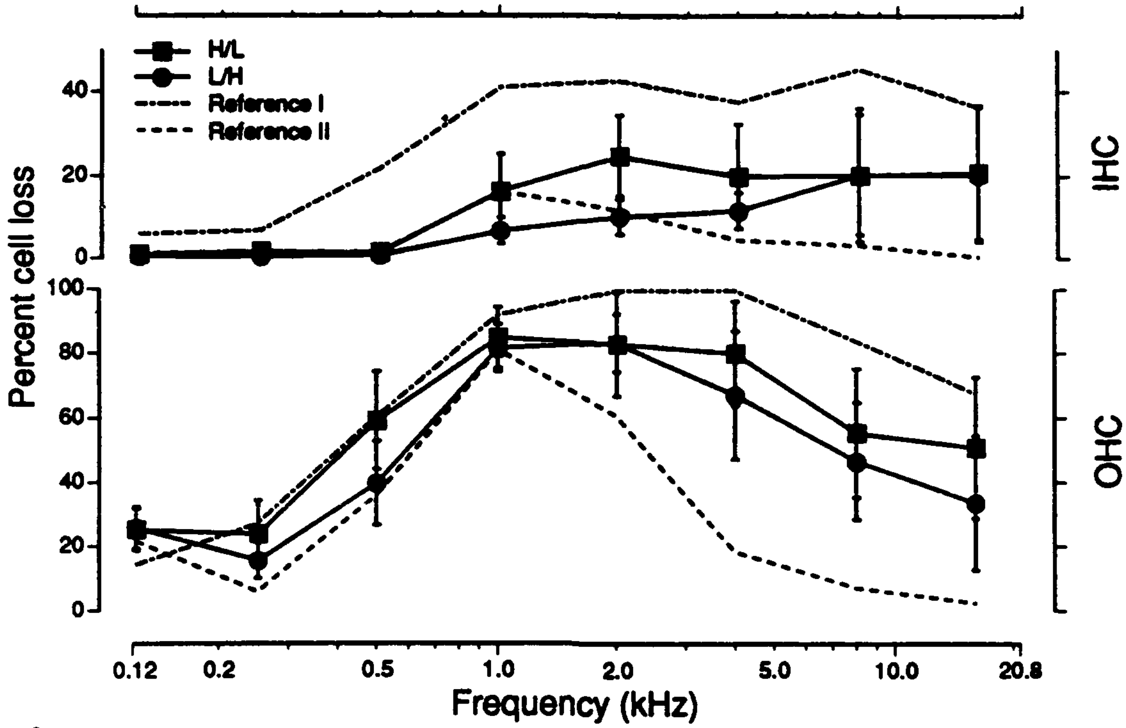


Figure 15. ***The group mean inner and outer hair cell losses computed over octave band lengths of the cochlea at the given frequencies for each of the experimental groups***

Table 3

Analysis of Variance Summary Table for Equal Energy Groups

Maximum Threshold Shift

Source of Variation	SS	df	MS	F	p
Exposure	1489.27	2	744.64	1.56	.243
Between Subjects	7163.13	15	477.54		
Frequency	8159.01	8	1019.88	20.99	.000
Exposure x Frequency	1455.17	16	90.95	1.87	.030
Within Subjects	5830.70	120	48.59		

Permanent Threshold Shift

Source of Variation	SS	df	MS	F	p
Exposure	3745.29	2	1872.64	1.85	.192
Between Subjects	15191.06	15	1012.74		
Frequency	4492.21	8	561.53	11.64	.000
Exposure x Frequency	1573.28	16	98.33	2.04	.016
Within Subjects	5789.91	120	48.25		

Percent Inner Hair Cell Loss

Source of Variation	SS	df	MS	F	p
Exposure	1650.59	2	825.29	.77	.481
Between Subjects	16111.23	15	1074.08		
Frequency	5480.32	7	782.90	2.97	.007
Exposure x Frequency	3239.62	14	231.40	.88	.584
Within Subjects	27655.14	105	263.38		

Percent Outer Hair Cell Loss

Source of Variation	SS	df	MS	F	p
Exposure	21062.04	2	10531.02	2.67	.102
Between Subjects	59212.74	15	3947.52		
Frequency	73146.45	7	10449.49	19.12	.000
Exposure x Frequency	12712.97	14	908.07	1.66	.075
Within Subjects	57390.27	105	546.57		

order of impulse presentation was not statistically significant for any of the four dependent measures employed. Likewise, there were no statistically significant interactions between order and frequency although this interaction approached statistical significance for the PTS measure ($F = 1.95$, df - 9/90, $p < .055$). The main effect of frequency was statistically significant for all analyses.

Conclusions

Based upon a visual inspection of the mean data shown in Figures 14 and 15, there would appear to be clear differences between the L/H and H/L groups for the PTS measures and clear differences between the three equal energy groups for the PTS and cell loss measures. However, the standard deviations in these data are large, for example, on the order of 15 to 20 dB for the PTS data (See Appendix). Thus, while the mean data and the statistical analysis are suggestive of some potentially interesting effects, it is going to be necessary to increase the experimental sample size before clear statements can be made about the effects of the presentation order of impulses or how to evaluate exposures with variable peak intensities. The one clear conclusion from these data is that the Reference I and II exposure conditions do clearly represent upper and lower bounds to the pathology produced in the L/H and H/L groups.

Table 4

Analysis of Variance Summary Table for L/H and H/L groups

Maximum Threshold Shift

Source of Variation	SS	df	MS	F	p
Order	1755.68	1	1755.68	4.43	.062
Between Subjects	3961.02	10	396.10		
Frequency	5019.17	9	557.69	13.48	.000
Order x Frequency	312.57	9	34.73	.84	.582
Within Subjects	3723.15	90	41.37		

Permanent Threshold Shift

Source of Variation	SS	df	MS	F	p
Order	2081.25	1	2081.25	1.40	.263
Between Subjects	14819.43	10	1481.94		
Frequency	3735.04	9	415.00	7.80	.000
Order x Frequency	932.39	9	103.60	1.95	.055
Within Subjects	4787.35	90	53.19		

Percent Inner Hair Cell Loss

Source of Variation	SS	df	MS	F	p
Order	465.96	1	465.96	.30	.596
Between Subjects	15546.79	10	1554.68		
Frequency	6469.36	7	924.19	2.53	.022
Order x Frequency	668.48	7	95.50	.26	.967
Within Subjects	25587.19	70	365.53		

Percent Outer Hair Cell Loss

Source of Variation	SS	df	MS	F	p
Order	1774.47	1	1774.47	.32	.585
Between Subjects	55749.21	10	5574.92		
Frequency	50541.46	7	7220.21	10.82	.000
Order x Frequency	1210.33	7	172.90	.26	.968
Within Subjects	46732.52	70	667.61		

References

CHABA. 1968. National Academy of Sciences, Committee on Hearing, Bioacoustics and Biomechanics. Proposed damage risk criterion for impulse noise (gunfire). Report of Working Group 57, NAS-NRC, Washington, D.C.

Department of Defense. 1979. Noise limits for Army material. Washington, D.C., Department of Defense, MIL-STD-1474(c).

Fay, R.R. 1988. Hearing in vertebrates. A psychophysics Databook. Hill-Fay Associates, Winnetka, IL.

Hamernik, R.P., Ahroon, W.A. and Patterson, Jr., J.H. 1988. Threshold recovery functions following impulse noise trauma. Journal of acoustical society of America, 84:941-950.

Miller, J.D. 1970. Audibility curve of the chinchilla. Journal of acoustical society of America, 48:513-523.

Patterson, Jr., J.H., Lomba Gautier, I.M., Curd, D.L., Hamernik, R.P., Salvi, R.J., Hargett, Jr., C.E., and Turrentine, G. 1986. The role of peak pressure in determining the auditory hazard of impulse noise. USAARL report No. 86-7.

Young, R.W. 1970. On the energy transported with a sound pulse. Journal of acoustical society of America, 47:441-442.

Appendix

Individual data and group
summary statistics

Guide to the appendix

The individual and summary statistics for each experimental group are presented in the appendix that follows. The following paragraphs present a brief description of the contents of the data appendix. In this summary, only a single exposure group is described. All the remaining exposure groups are organi''ed in the same manner.

Group title page

The group title page indicates the exposure that each animal in this group received [e.g., 138 dB peak SPL (90x), 146 dB peak SPL (10X)] and the subjects that comprise this group.

Preexposure and permanent threshold shift audiograms

The top panel depicts the mean preexposure thresholds for this group. The error bars on this figure and all others in the appendix represent one standard deviation plotted above and below the mean. The lower panel presents the group mean PTS.

Preexposure, postexposure and PTS measurements

This page tabulates the pre- and postexposure thresholds (in dB SPL) for each subject as well as the group mean and standard deviation. PTS is computed by subtracting the preexposure threshold from the postexposure threshold for each subject.

Recovery threshold shifts

The threshold shifts measured at frequency intervals following noise exposure are in this table.

Total cell loss summary

The total sensory cell losses for this group are presented in the top portion of this table. The lower position of the table presents the mean and standard deviation for the total number of inner and outer hair cells missing along octave band lengths of the cochlea.

Total cell losses

The total sensory cell losses in octave band lengths of the cochlea for each animal that comprises the exposure group are presented in this table. Also included at the end of the table are the group mean and standard deviation for each octave band length.

Percent sensory cell losses

This table presents the percent sensory cell losses in octave band lengths of the cochlea for each animal in this group. Also included are the means and standard deviation for each sensory cell and octave band length.

Cochleograms and PTS audiograms

These figures present cochleograms and PTS audiograms for each animal in the exposure group. The cochleograms show the percent inner and outer hair cell losses for each 0.24 mm segment of the basilar membrane. The PTS audiogram is plotted to allow easy comparison of the PTS and cell loss resulting from the noise exposure.

Index of all subjects and figures included in the present report

Subject	Group	Designation	Summary	PRE/PTS Cochleogram
G28	1	L/H		
H47	2	H/L		
H52	1	L/H		
H54	1	L/H		
H60	1	L/H		
H61	1	L/H		
H61B	2	H/L		
H65	1	L/H		
H153	2	H/L		
H225	2	H/L		
J30	2	H/L		
J36	2	H/L		

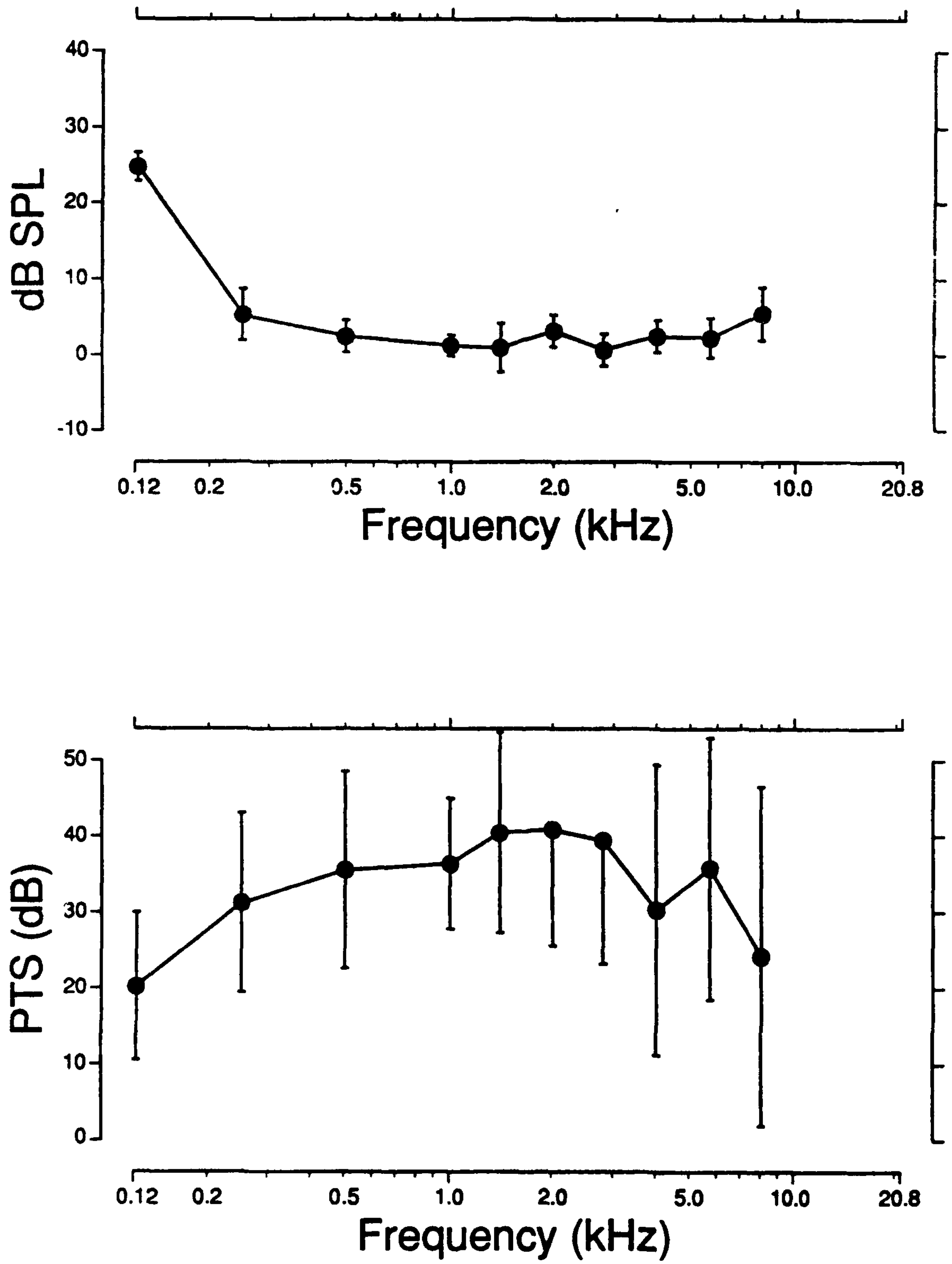
Summary data for the group exposed to:

138 dB peak SPL (90X), 146 dB peak SPL (10X)

Animal #

G28	-	Completed the entire protocol
H52	-	Completed the entire protocol
H54	-	Completed the entire protocol
H60	-	Completed the entire protocol
H61	-	Completed the entire protocol
H65	-	Completed the entire protocol

138 dB peak SPL (90X), 146 dB peak SPL (10X)



138 dB peak SPL (90X), 146 dB peak SPL (10X)

Preexposure thresholds (dB SPL)

Animal\kHz	.125	.25	0.5	1.0	1.4	2.0	2.8	4.0	5.7	8.0
G028	26.0	8.0	5.0	3.0	-1.0	1.0	-1.0	0.0	2.0	7.0
H052	28.0	7.0	3.0	2.0	-2.0	4.0	4.0	3.0	1.0	8.0
H054	23.0	1.0	0.0	1.0	-1.0	4.0	-1.0	0.0	0.0	2.0
H060	24.0	8.0	4.0	1.0	6.0	5.0	2.0	5.0	6.0	10.0
H061	23.0	1.0	0.0	-1.0	0.0	0.0	-1.0	3.0	0.0	1.0
H065	25.0	7.0	3.0	2.0	4.0	5.0	1.0	4.0	5.0	5.0
Mean	24.8	5.3	2.5	1.3	1.0	3.2	0.7	2.5	2.3	5.5
S.D.	1.9	3.4	2.1	1.4	3.2	2.1	2.1	2.1	2.6	3.5

Postexposure thresholds (dB SPL)

Animal\kHz	.125	.25	0.5	1.0	1.4	2.0	2.8	4.0	5.7	8.0
G028	38.8	23.5	25.3	28.3	42.5	42.0	34.8	19.0	23.3	26.5
H052	48.0	45.3	46.0	43.0	46.5	49.8	49.5	46.5	44.0	36.3
H054	58.3	42.3	45.8	46.5	46.3	61.5	55.3	54.0	55.5	57.5
H060	40.0	41.5	41.5	39.3	42.3	42.0	40.8	32.3	33.0	10.0
H061	50.8	42.5	48.3	41.3	51.8	50.8	49.0	41.0	53.5	43.0
H065	34.8	24.5	21.8	28.0	19.8	18.3	11.0	4.5	19.8	5.5
Mean	45.1	36.6	38.1	37.7	41.5	44.0	40.0	32.9	38.2	29.8
S.D.	8.8	9.8	11.6	7.8	11.2	14.5	16.0	18.4	15.2	19.9

Permanent threshold shift (dB)

Animal\kHz	.125	.25	0.5	1.0	1.4	2.0	2.8	4.0	5.7	8.0
G028	12.8	15.5	20.3	25.3	43.5	41.0	35.8	19.0	21.3	19.5
H052	20.0	38.3	43.0	41.0	48.5	45.8	45.5	43.5	43.0	28.3
H054	35.3	41.3	45.8	45.5	47.3	57.5	56.3	54.0	55.5	55.5
H060	16.0	33.5	37.5	38.3	36.3	37.0	38.8	27.3	27.0	0.0
H061	27.8	41.5	48.3	42.3	51.8	50.8	50.0	38.0	53.5	42.0
H065	9.8	17.5	18.8	26.0	15.8	13.3	10.0	0.5	14.8	0.5
Mean	20.3	31.3	35.6	36.4	40.5	40.9	39.4	30.4	35.8	24.3
S.D.	9.7	11.8	13.0	8.6	13.2	15.3	16.2	19.1	17.2	22.3

Temporary Threshold Shift (dB): 138 dB peak SPL (90X), 146 dB peak SPL (10X)

Frequency 0.125 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	50.0	45.0	31.0	58.0	42.0	40.0	31.0	19.0	15.0	26.0	12.0	20.0	15.0	19.0	11.0	6.0	58.0
H52	63.0	66.0	37.0	62.0	34.0	38.0	53.0	49.0	37.0	33.0	16.0	19.0	20.0	25.0	23.0	12.0	66.0
H54	57.0	56.0	52.0	45.0	57.0	65.0	67.0	57.0	55.0	35.0	25.0	29.0	54.0	35.0	24.0	28.0	67.0
H60	61.0	53.0	48.0	51.0	50.0	49.0	63.0	44.0	43.0	31.0	33.0	23.0	18.0	16.0	19.0	11.0	63.0
H61	25.0	59.0	55.0	36.0	43.0	45.0	55.0	45.0	57.0	53.0	44.0	39.0	33.0	33.0	24.0	21.0	59.0
H65	43.0	58.0	55.0	62.0	61.0	61.0	37.0	39.0	26.0	17.0	12.0	10.0	9.0	10.0	12.0	8.0	62.0
Mean	49.8	56.2	46.3	52.3	47.8	49.7	51.0	42.2	38.8	32.5	23.7	23.3	24.8	23.0	18.8	14.3	62.5
S.D.	14.2	7.0	10.1	10.4	10.1	11.1	14.3	12.8	16.4	11.9	12.9	9.9	16.3	9.8	6.0	8.5	3.6

Frequency 0.250 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	56.0	61.0	35.0	63.0	74.0	48.0	39.0	33.0	23.0	27.0	24.0	24.0	14.0	17.0	13.0	18.0	74.0
H52	63.0	65.0	57.0	48.0	55.0	74.0	66.0	45.0	58.0	56.0	42.0	34.0	35.0	33.0	42.0	43.0	74.0
H54	78.0	53.0	68.0	51.0	76.0	55.0	64.0	59.0	69.0	49.0	41.0	43.0	47.0	39.0	38.0	41.0	78.0
H60	78.0	55.0	70.0	62.0	62.0	65.0	59.0	60.0	49.0	47.0	41.0	29.0	33.0	38.0	35.0	28.0	78.0
H61	71.0	79.0	69.0	52.0	61.0	51.0	61.0	74.0	57.0	62.0	44.0	52.0	42.0	45.0	46.0	33.0	79.0
H65	45.0	66.0	69.0	79.0	65.0	66.0	45.0	48.0	44.0	33.0	31.0	13.0	21.0	24.0	19.0	6.0	79.0
Mean	65.2	63.2	61.3	59.2	65.5	59.8	55.7	53.2	50.0	45.7	37.2	32.5	32.0	32.7	32.2	28.2	77.0
S.D.	13.1	9.3	13.8	11.5	8.1	10.1	11.0	14.2	15.7	13.4	7.9	13.8	12.5	10.4	13.2	14.2	2.4

Frequency 0.500 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	54.0	61.0	57.0	66.0	76.0	38.0	54.0	27.0	43.0	-1.0	32.0	36.0	19.0	19.0	27.0	16.0	76.0
H52	68.0	51.0	69.0	66.0	75.0	71.0	73.0	70.0	47.0	44.0	45.0	54.0	53.0	28.0	50.0	41.0	75.0
H54	60.0	67.0	77.0	55.0	64.0	65.0	98.0	70.0	72.0	56.0	87.0	48.0	64.0	41.0	40.0	38.0	98.0
H60	66.0	68.0	67.0	73.0	83.0	82.0	67.0	61.0	53.0	47.0	37.0	38.0	44.0	38.0	32.0	36.0	83.0
H61	68.0	70.0	81.0	78.0	67.0	55.0	95.0	78.0	79.0	59.0	45.0	47.0	48.0	53.0	54.0	38.0	95.0
H65	53.0	53.0	67.0	77.0	76.0	67.0	42.0	37.0	25.0	31.0	22.0	24.0	25.0	8.0	18.0	24.0	77.0
Mean	61.5	61.7	69.7	69.2	73.5	63.0	71.5	57.2	53.2	39.3	44.7	41.2	42.2	31.2	36.8	32.2	84.0
S.D.	6.9	8.1	8.5	8.7	6.9	15.1	22.2	20.5	19.8	22.1	22.5	10.7	17.1	16.2	13.8	9.9	10.1

Temporary Threshold Shift (dB): 138 dB peak SPL (90X), 146 dB peak SPL (10X)

Frequency 1.000 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	70.0	51.0	75.0	78.0	75.0	53.0	44.0	37.0	42.0	31.0	25.0	34.0	13.0	29.0	37.0	22.0	78.0
H52	46.0	69.0	67.0	78.0	82.0	79.0	76.0	29.0	47.0	48.0	49.0	34.0	44.0	46.0	39.0	35.0	82.0
H54	57.0	63.0	68.0	90.0	86.0	80.0	83.0	63.0	85.0	61.0	43.0	40.0	51.0	49.0	47.0	35.0	90.0
H60	77.0	68.0	64.0	79.0	86.0	91.0	61.0	54.0	44.0	38.0	39.0	40.0	35.0	40.0	41.0	37.0	91.0
H61	41.0	63.0	69.0	80.0	84.0	82.0	52.0	67.0	60.0	64.0	47.0	56.0	42.0	37.0	43.0	47.0	84.0
H65	46.0	60.0	60.0	69.0	69.0	57.0	39.0	40.0	34.0	30.0	10.0	13.0	20.0	26.0	28.0	30.0	69.0
Mean	56.2	62.3	67.2	79.0	80.3	73.7	59.2	48.3	52.0	45.3	35.5	36.2	34.2	37.8	39.2	34.3	82.3
S.D.	14.6	6.5	5.0	6.7	6.9	15.1	17.6	15.3	18.3	14.8	15.1	13.9	14.8	9.1	6.5	8.2	8.2

Frequency 1.400 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	65.0	69.0	87.0	73.0	56.0	60.0	51.0	52.0	54.0	48.0	57.0	56.0	40.0	46.0	38.0	50.0	87.0
H52	65.0	70.0	79.0	84.0	63.0	75.0	81.0	57.0	49.0	46.0	55.0	47.0	44.0	47.0	56.0	47.0	84.0
H54	67.0	56.0	69.0	82.0	89.0	94.0	85.0	77.0	77.0	62.0	65.0	52.0	53.0	44.0	47.0	45.0	94.0
H60	81.0	70.0	63.0	67.0	78.0	82.0	56.0	57.0	50.0	41.0	31.0	37.0	39.0	43.0	32.0	31.0	82.0
H61	62.0	71.0	76.0	82.0	82.0	71.0	81.0	75.0	65.0	65.0	59.0	56.0	59.0	49.0	53.0	46.0	82.0
H65	53.0	74.0	65.0	75.0	67.0	61.0	43.0	42.0	22.0	11.0	19.0	29.0	19.0	11.0	9.0	24.0	75.0
Mean	65.5	68.3	73.2	77.2	72.5	73.8	66.2	60.0	52.8	45.5	47.7	46.2	42.3	40.0	39.2	40.5	84.0
S.D.	9.1	6.3	9.2	6.6	12.5	13.0	18.2	13.6	18.5	19.3	18.3	11.0	13.8	14.4	17.3	10.4	6.3

Frequency 2.000 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	80.0	76.0	80.0	83.0	83.0	60.0	68.0	58.0	50.0	56.0	49.0	49.0	40.0	36.0	51.0	37.0	83.0
H52	52.0	73.0	63.0	80.0	77.0	82.0	69.0	51.0	44.0	70.0	53.0	42.0	50.0	51.0	41.0	41.0	82.0
H54	57.0	63.0	65.0	75.0	69.0	82.0	77.0	74.0	75.0	74.0	64.0	61.0	61.0	54.0	57.0	58.0	82.0
H60	76.0	71.0	73.0	73.0	81.0	86.0	60.0	68.0	53.0	39.0	40.0	41.0	38.0	38.0	36.0	36.0	86.0
H61	62.0	70.0	83.0	81.0	80.0	79.0	79.0	82.0	53.0	69.0	58.0	48.0	55.0	51.0	52.0	45.0	83.0
H65	72.0	56.0	68.0	68.0	66.0	68.0	35.0	35.0	21.0	2.0	23.0	12.0	11.0	19.0	7.0	16.0	72.0
Mean	66.5	68.2	72.0	76.7	76.0	76.2	64.7	61.3	49.3	51.7	47.8	42.2	42.5	41.5	40.7	38.8	81.3
S.D.	11.2	7.4	8.1	5.7	6.9	10.0	16.1	17.0	17.4	27.5	14.6	16.4	17.7	13.3	18.2	13.7	4.8

Temporary Threshold Shift (dB): 136 dB peak SPL (90X), 146 dB peak SPL (10X)

Frequency 2.800 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	71.0	75.0	75.0	78.0	74.0	59.0	48.0	48.0	25.0	43.0	53.0	57.0	27.0	43.0	45.0	28.0	78.0
H52	61.0	69.0	75.0	70.0	78.0	67.0	71.0	63.0	34.0	49.0	36.0	49.0	51.0	41.0	51.0	39.0	78.0
H54	73.0	79.0	86.0	85.0	81.0	69.0	83.0	75.0	65.0	75.0	69.0	65.0	46.0	61.0	60.0	58.0	86.0
H60	67.0	67.0	66.0	67.0	74.0	77.0	57.0	59.0	61.0	52.0	42.0	42.0	40.0	41.0	37.0	37.0	77.0
H61	62.0	73.0	73.0	67.0	87.0	65.0	75.0	75.0	61.0	61.0	48.0	45.0	53.0	49.0	50.0	48.0	87.0
H65	54.0	58.0	62.0	74.0	62.0	61.0	47.0	31.0	42.0	-2.0	-1.0	8.0	20.0	3.0	9.0	8.0	74.0
Mean	64.7	70.2	72.8	73.5	76.0	66.3	63.5	58.[illegible]	48.0	46.3	41.2	44.3	39.5	39.7	42.0	36.3	80.0
S.D.	7.1	7.3	8.3	7.1	8.4	6.4	15.0	16.[illegible]	16.7	26.2	23.5	19.7	13.4	19.5	17.8	17.2	5.3

Frequency 4.000 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	70.0	70.0	50.0	74.0	74.0	60.0	45.0	34.0	27.0	40.0	58.0	58.0	23.0	19.0	20.0	14.0	74.0
H52	54.0	66.0	70.0	83.0	64.0	69.0	67.0	38.0	46.0	36.0	39.0	39.0	44.0	39.0	47.0	44.0	83.0
H54	59.0	76.0	70.0	62.0	59.0	61.0	66.0	63.0	65.0	63.0	66.0	45.0	53.0	57.0	61.0	45.0	76.0
H60	66.0	65.0	69.0	65.0	66.0	68.0	51.0	53.0	34.0	34.0	31.0	32.0	35.0	30.0	18.0	26.0	69.0
H61	40.0	56.0	67.0	66.0	68.0	69.0	59.0	64.0	49.0	59.0	33.0	32.0	27.0	47.0	48.0	30.0	69.0
H65	34.0	59.0	61.0	68.0	59.0	64.0	8.0	18.0	11.0	6.0	0.0	8.0	10.0	-2.0	-5.0	-1.0	68.0
Mean	53.8	65.3	64.5	69.7	65.0	65.2	49.3	45.0	38.7	39.7	37.8	35.7	32.0	31.7	31.5	26.3	73.2
S.D.	14.3	7.3	7.9	7.7	5.7	4.1	22.0	18.2	18.9	20.5	23.3	16.7	15.4	21.1	24.6	17.7	5.8

Frequency 5.700 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	41.0	60.0	64.0	58.0	92.0	32.0	66.0	23.0	26.0	38.0	46.0	44.0	12.0	25.0	28.0	20.0	92.0
H52	65.0	68.0	61.0	73.0	82.0	61.0	82.0	60.0	67.0	56.0	54.0	67.0	50.0	33.0	47.0	42.0	82.0
H54	85.0	71.0	86.0	74.0	83.0	59.0	77.0	74.0	64.0	87.0	90.0	77.0	58.0	73.0	71.0	20.0	90.0
H60	63.0	56.0	58.0	65.0	66.0	71.0	54.0	45.0	35.0	31.0	24.0	30.0	25.0	29.0	21.0	33.0	71.0
H61	64.0	62.0	81.0	60.0	70.0	64.0	74.0	69.0	60.0	71.0	61.0	46.0	51.0	63.0	59.0	41.0	81.0
H65	16.0	52.0	60.0	65.0	54.0	61.0	21.0	11.0	16.0	8.0	11.0	6.0	14.0	9.0	24.0	12.0	65.0
Mean	55.7	61.5	68.3	65.8	74.5	58.0	62.3	47.0	44.7	48.5	47.7	45.0	35.0	38.7	41.7	28.0	80.2
S.D.	23.9	7.1	12.0	6.6	13.8	13.4	22.5	25.5	21.8	28.6	28.0	25.5	20.4	24.3	20.6	12.4	10.5

Temporary Threshold Shift (dB): 138 dB peak SPL (90X), 146 dB peak SPL (10X)

Frequency 8.000 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
G28	30.0	32.0	46.0	49.0	41.0	51.0	33.0	23.0	5.0	14.0	34.0	22.0	7.0	37.0	20.0	14.0	51.0
H52	42.0	55.0	38.0	66.0	52.0	56.0	62.0	30.0	23.0	34.0	32.0	25.0	31.0	18.0	46.0	18.0	66.0
H54	48.0	57.0	80.0	72.0	79.0	71.0	71.0	64.0	82.0	69.0	69.0	51.0	54.0	58.0	57.0	53.0	82.0
H60	34.0	49.0	51.0	49.0	64.0	38.0	46.0	37.0	24.0	11.0	16.0	7.0	2.0	-4.0	-2.0	4.0	64.0
H61	59.0	88.0	70.0	62.0	50.0	73.0	73.0	65.0	53.0	51.0	55.0	33.0	51.0	37.0	35.0	45.0	88.0
H65	27.0	63.0	63.0	62.0	65.0	64.0	22.0	25.0	38.0	13.0	12.0	6.0	0.0	1.0	-2.0	3.0	65.0
Mean	40.0	57.3	58.0	60.0	58.5	58.8	51.2	40.7	37.5	32.0	36.3	24.0	24.2	24.5	25.7	22.8	69.3
S.D.	12.1	18.4	15.8	9.3	13.5	13.3	21.0	19.1	27.1	23.9	22.1	16.9	24.6	23.8	24.7	21.2	13.4

Summary of Group Anatomical Data with

Cochleograms and PTS Audiograms

for Individual Animals

138 dB peak SPL (90X), 146 dB peak SPL (10X)

Total number of cochlear sensory cells missing

Animal number	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Total outer hair cells
G28	17	614	672	522	1808
H52	91	1267	1225	1173	3665
H54	415	1661	1596	1300	4557
H60	144	1324	1279	1044	3647
H61	230	1749	1753	1623	5125
H65	19	526	422	306	1254
Group mean	153				3343
S.D.	152				1521
S.E.	62				621

Total sensory cell losses over octave band lengths of the cochlea centered at the frequencies indicated

	Octave band center frequency	Inner hair cells	Outer hair cells
Group means			
	0.125 kHz	0.8	136.3
	0.25 kHz	1.0	141.3
	0.5 kHz	1.7	361.7
	1 kHz	15.0	715.5
	2 kHz	22.7	744.8
	4 kHz	26.5	586.8
	8 kHz	45.2	402.2
	16 kHz	39.8	254.0
Standard deviations			
	0.125 kHz	1.2	81.8
	0.25 kHz	1.3	113.2
	0.5 kHz	2.2	293.2
	1 kHz	17.1	132.7
	2 kHz	23.2	172.7
	4 kHz	25.1	423.5
	8 kHz	77.0	378.3
	16 kHz	76.9	390.6

138 dB peak SPL (90X), 146 dB peak SPL (10X)

Total sensory cell losses over octave band frequencies

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Chinchilla G28							
0.125 kHz	3	38	99	108	245	3	2
0.25 kHz	3	9	37	150	196	5	3
0.5 kHz	0	10	14	28	52	0	0
1 kHz	2	255	228	151	634	2	9
2 kHz	2	291	258	75	624	1	18
4 kHz	4	11	35	9	55	1	1
8 kHz	3	0	0	1	1	0	0
16 kHz	0	0	1	0	1	0	0
TOTALS	17	614	672	522	1808	12	33
Chinchilla H52							
0.125 kHz	0	3	9	46	58	0	0
0.25 kHz	0	33	7	48	88	0	0
0.5 kHz	1	265	227	139	631	0	1
1 kHz	39	290	289	247	826	119	82
2 kHz	35	296	296	283	875	66	42
4 kHz	14	296	296	293	885	0	8
8 kHz	2	84	99	113	296	0	1
16 kHz	0	0	2	4	6	1	0
TOTALS	91	1267	1225	1173	3665	186	134
Chinchilla H54							
0.125 kHz	1	88	89	54	231	0	0
0.25 kHz	0	144	133	62	339	0	0
0.5 kHz	1	120	75	16	211	0	0
1 kHz	0	258	250	175	683	1	5
2 kHz	1	270	268	219	757	3	17
4 kHz	23	270	270	263	803	51	51
8 kHz	197	270	270	270	810	294	206
16 kHz	192	241	241	241	723	382	239
TOTALS	415	1661	1596	1300	4557	731	518

138 dB peak SPL (90X), 146 dB peak SPL (10X)

Total sensory cell losses over octave band frequencies

Chinchilla H60

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
0.125 kHz	0	45	30	32	107	0	0
0.25 kHz	1	69	48	21	138	0	2
0.5 kHz	6	192	194	71	457	1	3
1 kHz	34	289	267	219	775	82	82
2 kHz	32	303	302	270	875	6	25
4 kHz	58	301	303	300	904	67	130
8 kHz	13	125	135	131	391	10	7
16 kHz	0	0	0	0	0	0	0
TOTALS	144	1324	1279	1044	3647	166	249

Chinchilla H61

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
0.125 kHz	0	27	20	18	65	0	0
0.25 kHz	2	14	27	4	45	0	0
0.5 kHz	1	267	266	212	745	1	40
1 kHz	10	289	289	287	865	2	66
2 kHz	59	296	296	288	880	92	77
4 kHz	57	296	295	254	845	11	33
8 kHz	54	296	296	296	888	2	13
16 kHz	47	264	264	264	792	1	7
TOTALS	230	1749	1753	1623	5125	109	236

Chinchilla H65

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
0.125 kHz	1	16	41	55	112	0	0
0.25 kHz	0	12	6	24	42	0	0
0.5 kHz	1	35	25	14	74	0	1
1 kHz	5	232	174	104	510	1	10
2 kHz	7	208	163	87	458	0	7
4 kHz	3	11	5	13	29	1	0
8 kHz	2	10	8	9	27	0	3
16 kHz	0	2	0	0	2	0	0
TOTALS	19	526	422	306	1254	2	21

138 dB peak SPL (90X), 146 dB peak SPL (10X)

Total sensory cell losses over octave band frequencies

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Group means							
0.125 kHz	0.8	36.2	48.0	52.2	136.3	0.5	0.3
0.25 kHz	1.0	46.8	43.0	51.5	141.3	0.8	0.8
0.5 kHz	1.7	148.2	133.5	80.0	361.7	0.3	7.5
1 kHz	15.0	268.8	249.5	197.2	715.5	34.5	42.3
2 kHz	22.7	277.3	263.8	203.7	744.8	28.0	31.0
4 kHz	26.5	197.5	200.7	188.7	586.8	21.8	37.2
8 kHz	45.2	130.8	134.7	136.7	402.2	51.0	38.3
16 kHz	39.8	84.5	84.7	84.8	254.0	64.0	41.0
TOTALS	152.7	1190.2	1157.8	994.7	3342.7	201.0	198.5
Group standard deviations							
0.125 kHz	1.2	29.5	37.3	30.8	81.8	1.2	0.8
0.25 kHz	1.3	52.6	47.1	52.5	113.2	2.0	1.3
0.5 kHz	2.2	111.7	109.0	80.2	293.2	0.5	16.0
1 kHz	17.1	24.2	43.8	66.8	132.7	52.4	38.1
2 kHz	23.2	35.8	52.4	98.2	172.7	40.4	25.4
4 kHz	25.1	144.9	140.7	138.7	423.5	29.5	49.7
8 kHz	77.0	127.0	126.3	125.3	378.3	119.1	82.3
16 kHz	76.9	130.3	130.2	130.1	390.6	155.8	97.0
TOTALS	151.6	515.9	518.2	494.0	1520.9	270.6	183.9

138 dB peak SPL (90X), 146 dB peak SPL (10X)

Percent sensory cell losses over octave band frequencies

Chinchilla G28

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
0.125 kHz	2.1	20.2	52.7	57.4	43.4	1.1	1.1
0.25 kHz	1.2	2.7	11.2	45.5	19.8	1.0	0.9
0.5 kHz	0.0	3.0	4.2	8.5	5.2	0.0	0.0
1 kHz	0.8	81.2	72.6	48.1	67.3	0.4	2.9
2 kHz	0.8	90.9	80.6	23.4	65.0	0.2	5.6
4 kHz	1.6	3.4	10.9	2.8	5.7	0.2	0.3
8 kHz	1.2	0.0	0.0	0.3	0.1	0.0	0.0
16 kHz	0.0	0.0	0.3	0.0	0.1	0.0	0.0

Chinchilla H52

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
0.125 kHz	0.0	1.7	5.2	26.4	11.1	0.0	0.0
0.25 kHz	0.0	10.8	2.3	15.7	9.6	0.0	0.0
0.5 kHz	0.4	87.2	74.7	45.7	69.2	0.0	0.3
1 kHz	17.4	100.0	99.7	85.2	95.0	25.4	28.3
2 kHz	15.8	100.0	100.0	95.6	98.5	13.8	14.2
4 kHz	6.1	100.0	100.0	99.0	99.7	0.0	2.7
8 kHz	0.8	28.4	33.4	38.2	33.3	0.0	0.3
16 kHz	0.0	0.0	0.8	1.5	0.8	0.2	0.0

Chinchilla H54

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
0.125 kHz	0.8	55.7	56.3	34.2	48.7	0.0	0.0
0.25 kHz	0.0	51.6	47.7	22.2	40.5	0.0	0.0
0.5 kHz	0.5	43.3	27.1	5.8	25.4	0.0	0.0
1 kHz	0.0	97.7	94.7	66.3	86.2	0.2	1.9
2 kHz	0.5	100.0	99.3	81.1	93.5	0.7	6.3
4 kHz	10.8	100.0	100.0	97.4	99.1	11.7	18.9
8 kHz	90.4	100.0	100.0	100.0	100.0	67.6	76.3
16 kHz	99.0	100.0	100.0	100.0	100.0	98.2	99.2

138 dB peak SPL (90X), 146 dB peak SPL (10X)

Percent sensory cell losses over octave band frequencies

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Chinchilla H60							
0.125 kHz	0.0	25.3	16.9	18.0	20.1	0.0	0.0
0.25 kHz	0.4	22.0	15.3	6.7	14.7	0.0	0.6
0.5 kHz	2.6	61.5	62.2	22.8	48.8	0.2	1.0
1 kHz	14.8	97.3	89.9	73.7	87.0	17.1	27.6
2 kHz	14.1	100.0	99.7	89.1	96.3	1.2	8.3
4 kHz	24.5	99.3	100.0	99.0	99.4	13.7	42.9
8 kHz	5.3	41.1	44.4	43.1	42.9	2.0	2.3
16 kHz	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chinchilla H61							
0.125 kHz	0.0	15.5	11.5	10.3	12.4	0.0	0.0
0.25 kHz	0.9	4.6	8.9	1.3	4.9	0.0	0.0
0.5 kHz	0.4	87.8	87.5	69.7	81.7	0.2	13.2
1 kHz	4.5	100.0	100.0	99.3	99.8	0.4	22.8
2 kHz	26.7	100.0	100.0	97.3	99.1	19.3	26.0
4 kHz	24.7	100.0	99.7	85.8	95.2	2.3	11.1
8 kHz	22.7	100.0	100.0	100.0	100.0	0.4	4.4
16 kHz	22.1	100.0	100.0	100.0	100.0	0.2	2.7
Chinchilla H65							
0.125 kHz	0.7	8.3	21.2	28.5	19.3	0.0	0.0
0.25 kHz	0.0	3.6	1.8	7.1	4.2	0.0	0.0
0.5 kHz	0.4	10.4	7.4	4.1	7.3	0.0	0.3
1 kHz	2.0	72.3	54.2	32.4	53.0	0.2	3.1
2 kHz	2.8	63.4	49.7	26.5	46.5	0.0	2.1
4 kHz	1.2	3.4	1.5	4.0	3.0	0.2	0.0
8 kHz	0.8	3.0	2.4	2.7	2.7	0.0	0.9
16 kHz	0.0	0.7	0.0	0.0	0.2	0.0	0.0

138 dB peak SPL (90X), 146 dB peak SPL (10X)

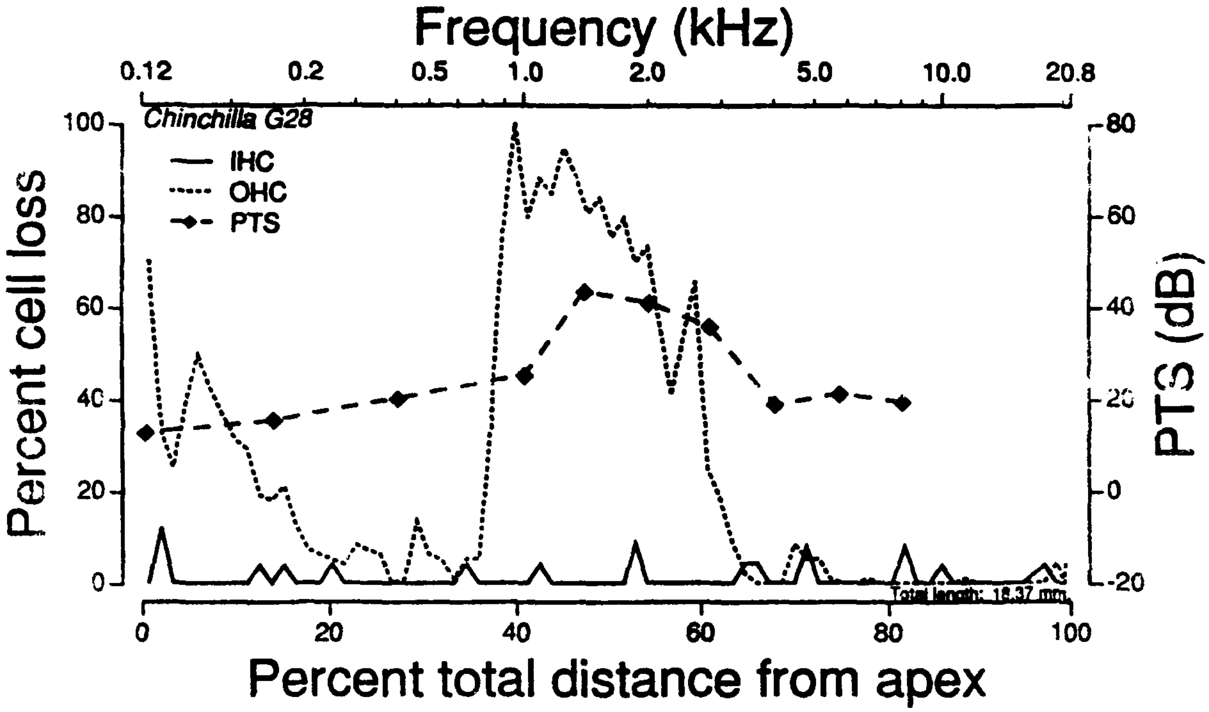
Percent sensory cell losses over octave band frequencies

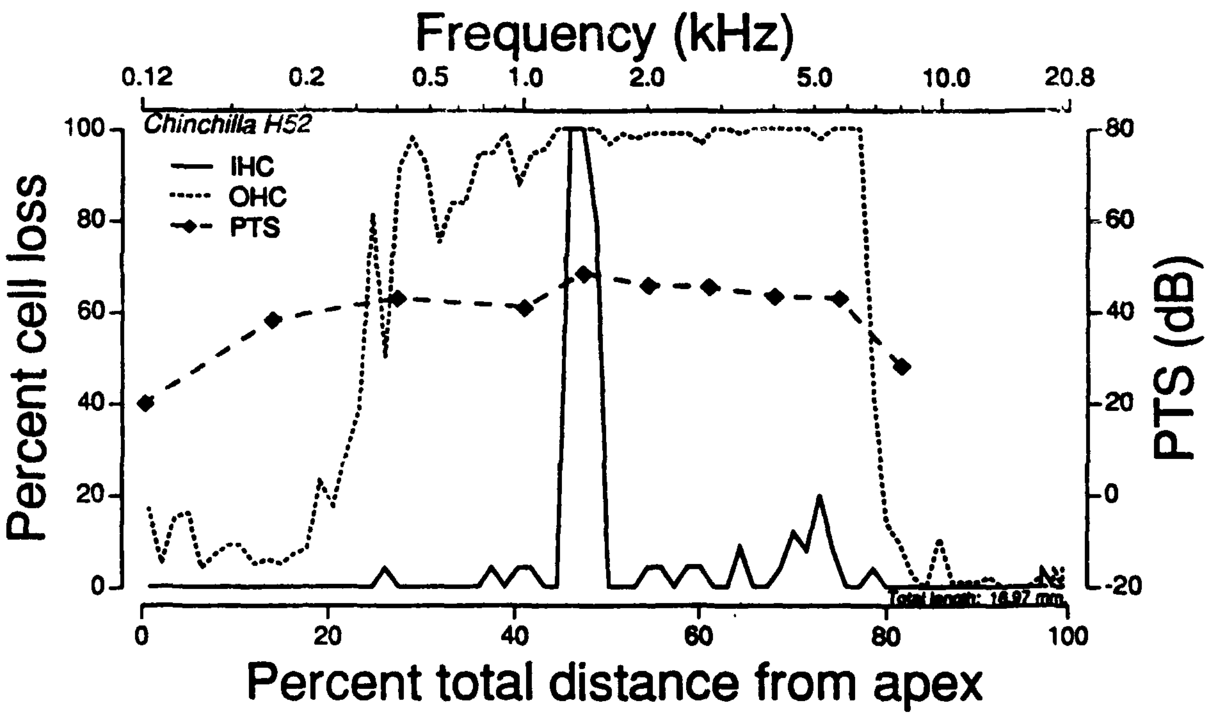
Group means

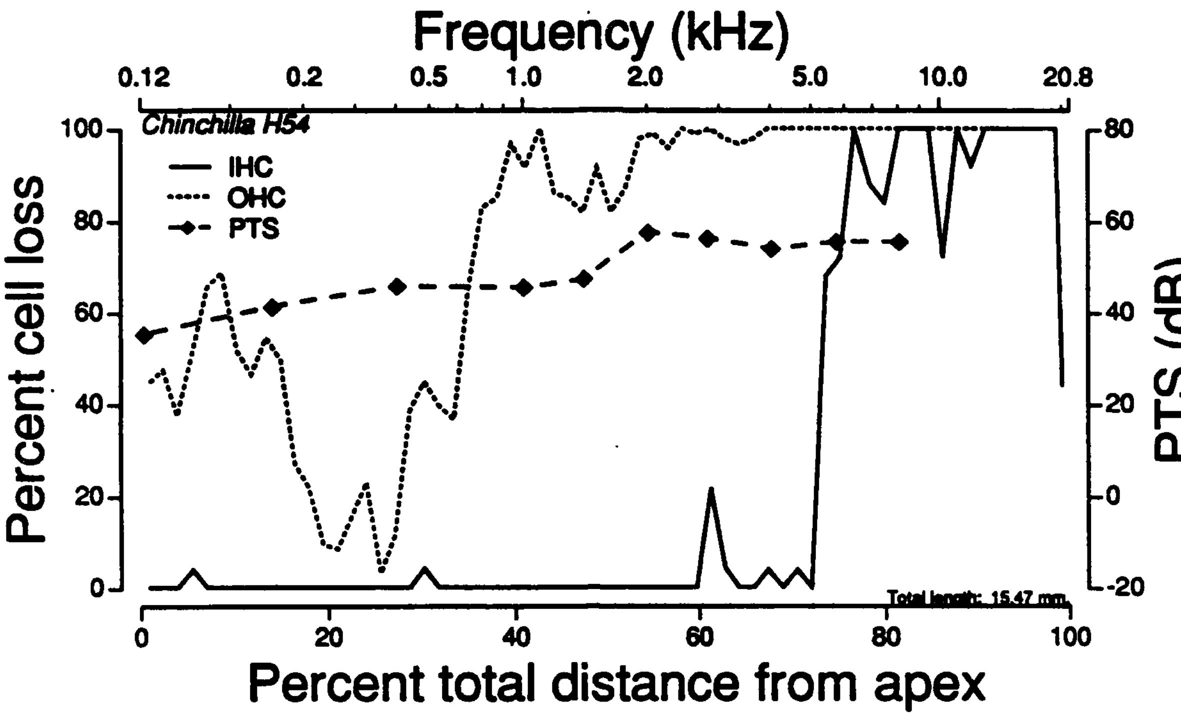
	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
0.125 kHz	0.60	21.12	27.30	29.13	25.85	0.18	0.18
0.25 kHz	0.42	15.88	14.53	16.42	15.61	0.17	0.25
0.5 kHz	0.72	48.87	43.85	26.10	39.61	0.07	2.47
1 kHz	6.58	91.42	85.18	67.50	81.37	7.28	14.43
2 kHz	10.12	92.38	88.22	68.83	83.14	5.87	10.42
4 kHz	11.48	67.68	68.68	64.67	67.01	4.68	12.65
8 kHz	20.20	45.42	46.70	47.38	46.50	11.67	14.03
16 kHz	20.18	33.45	33.52	33.58	33.52	16.43	16.98

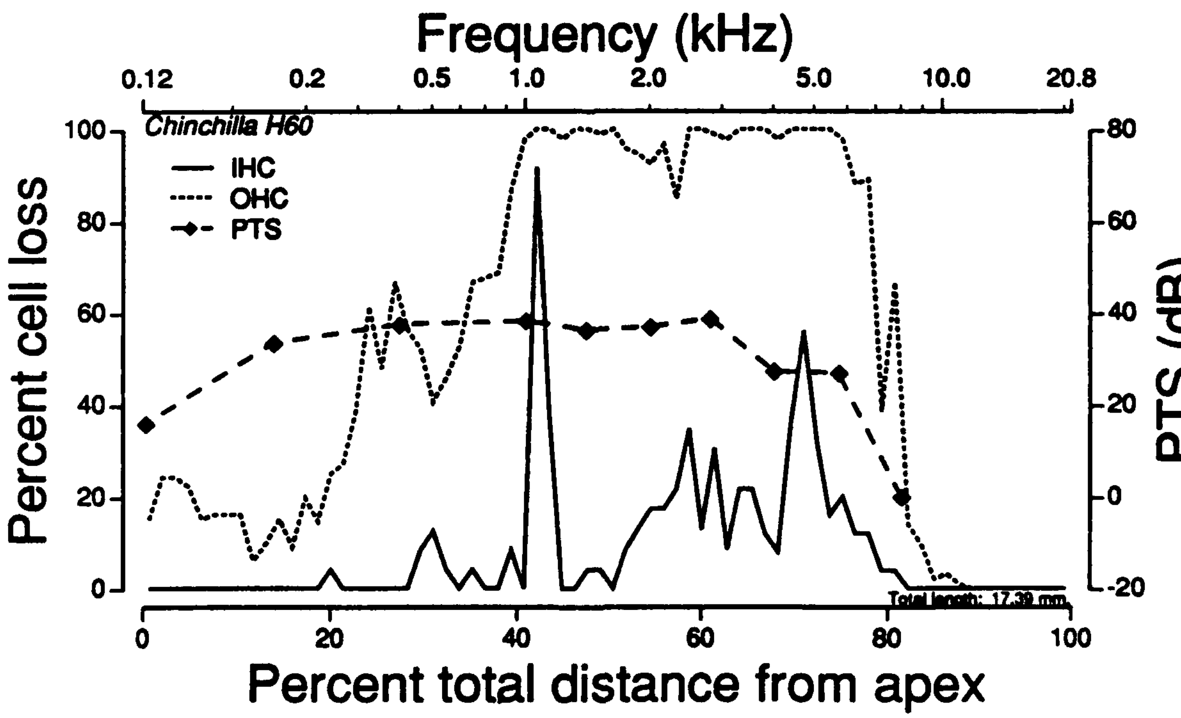
Group standard deviations

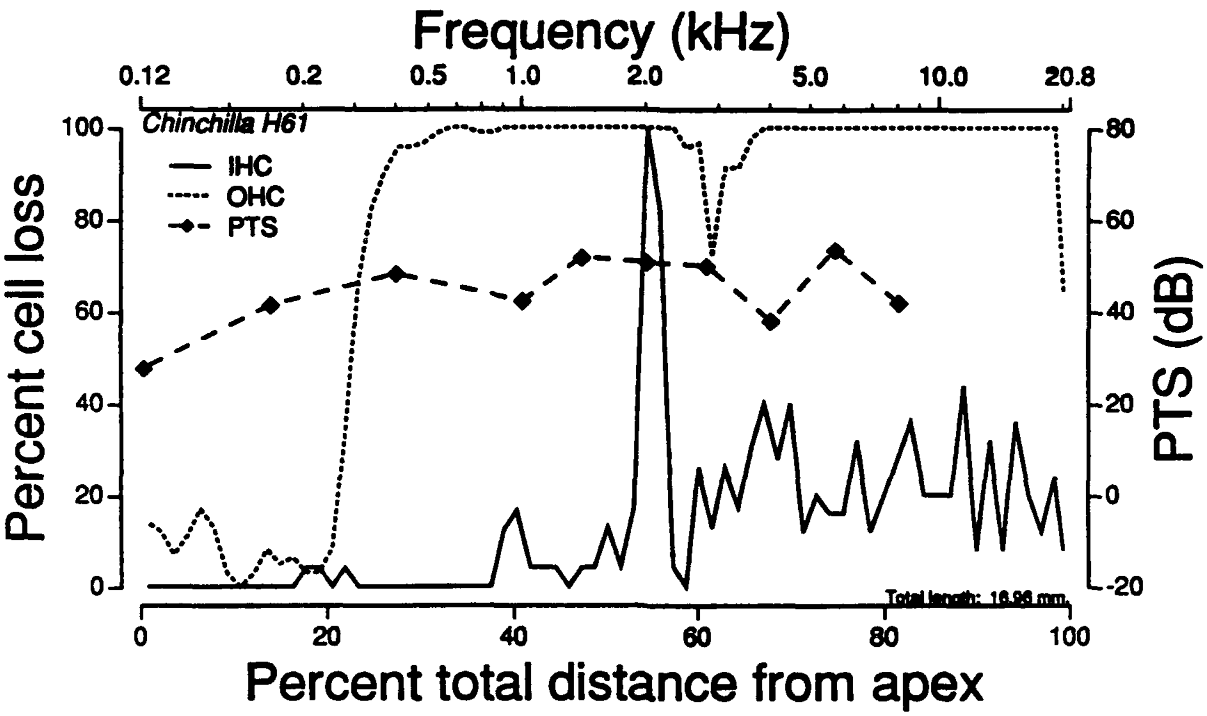
	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
0.125 kHz	0.82	10.91	21.77	16.19	16.16	0.45	0.45
0.25 kHz	0.52	18.93	17.06	16.06	13.56	0.41	0.40
0.5 kHz	0.94	36.77	35.71	26.46	32.12	0.10	5.27
1 kHz	7.57	11.76	18.23	24.38	17.79	11.13	13.07
2 kHz	10.55	14.66	20.37	34.48	22.10	8.47	8.61
4 kHz	10.74	49.79	48.49	47.71	48.59	6.30	16.54
8 kHz	35.41	45.01	44.74	44.39	44.68	27.41	30.55
16 kHz	39.61	51.55	51.50	51.45	51.50	40.06	40.29

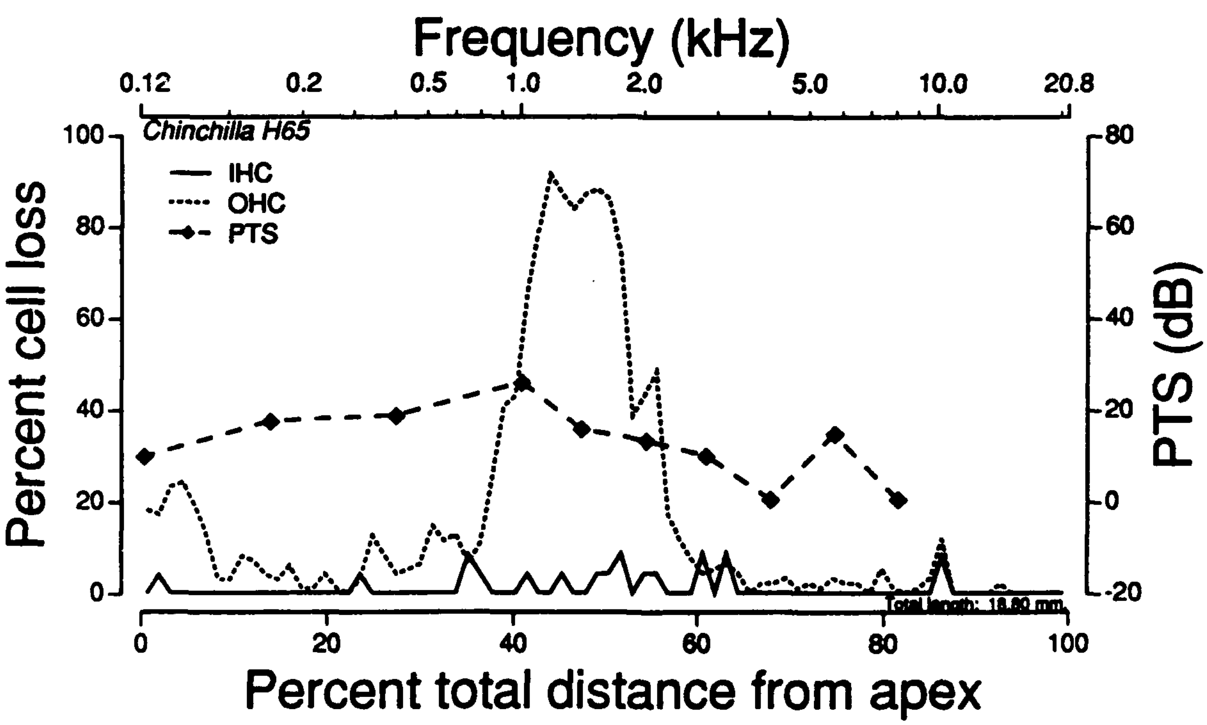

Frequency (kHz)
0.12
0.2
0.5
1.0
2.0
5.0
10.0
20.8
Chinchilla G28
IHC
OHC
PTS
Percent cell loss
PTS (dB)
Percent total distance from apex
Total length: 18.37 mm


Frequency (kHz)
0.12
0.2
0.5
1.0
2.0
5.0
10.0
20.8
Chinchilla H52
IHC
OHC
PTS
Percent cell loss
PTS (dB)
Percent total distance from apex
Total length: 18.97 mm


Frequency (kHz)
0.12 0.2 0.5 1.0 2.0 5.0 10.0 20.8
Chinchilla H54
IHC
OHC
PTS
Percent cell loss
PTS (dB)
Total length: 15.47 mm
Percent total distance from apex


Frequency (kHz)
0.12 0.2 0.5 1.0 2.0 5.0 10.0 20.8
Chinchilla H60
IHC
OHC
PTS
Percent cell loss
PTS (dB)
Total length: 17.39 mm
Percent total distance from apex


Frequency (kHz)
0.12
0.2
0.5
1.0
2.0
5.0
10.0
20.8
Chinchilla H61
IHC
OHC
PTS
Percent cell loss
PTS (dB)
Total length: 16.96 mm
Percent total distance from apex


Frequency (kHz)
0.12
0.2
0.5
1.0
2.0
5.0
10.0
20.8
Chinchilla H65
IHC
OHC
PTS
Percent cell loss
PTS (dB)
Total length: 18.80 mm
Percent total distance from apex

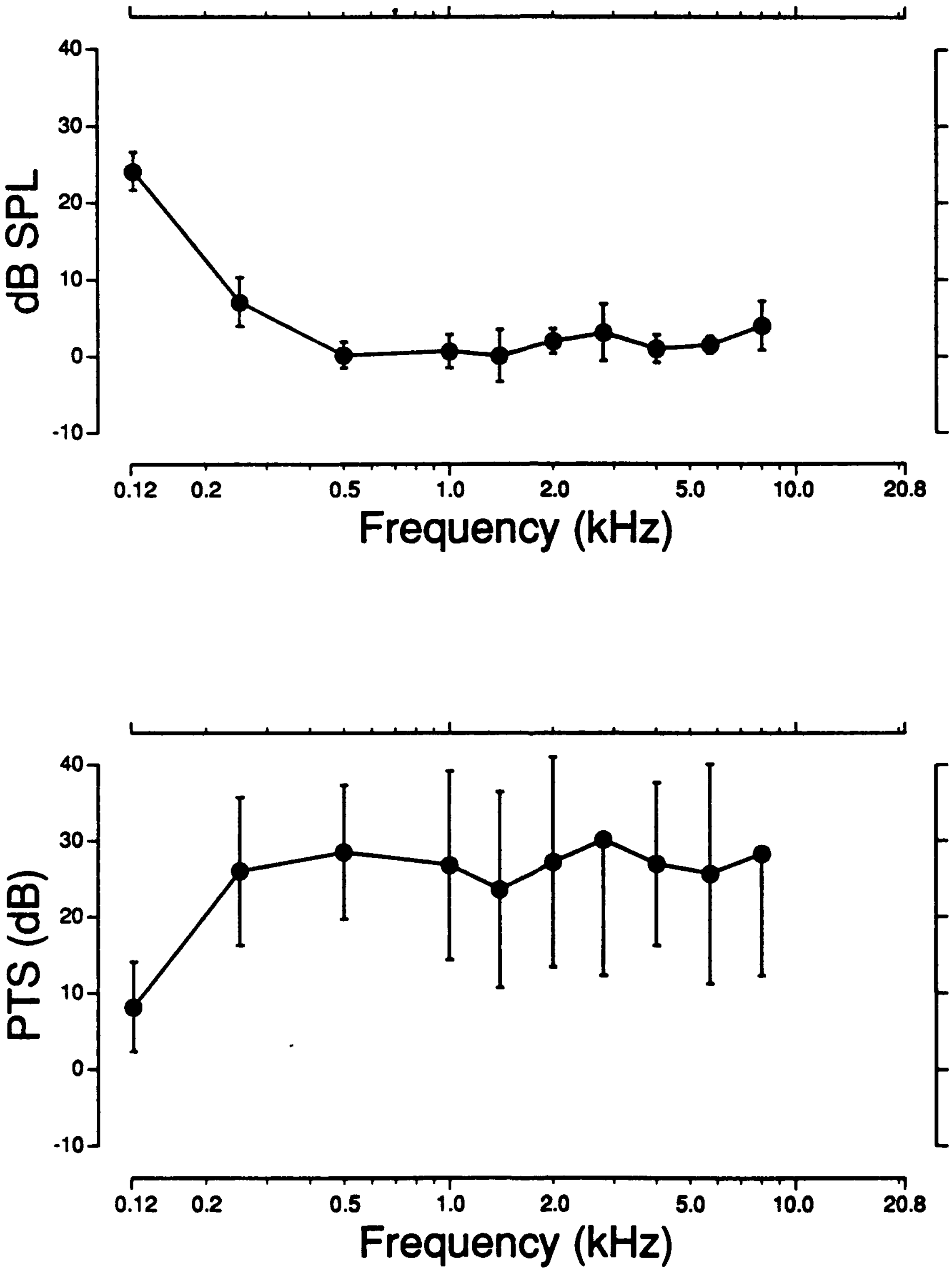
Summary data for the group exposed to:

146 dB peak SPL (10X), 138 dB peak SPL (90X)

Animal #

H47	-	Completed the entire protocol
H61R	-	Completed the entire protocol
H153	-	Completed the entire protocol
H225	-	Completed the entire protocol
J30	-	Completed the entire protocol
J36	-	Completed the entire protocol

146 dB peak SPL (10X), 138 dB peak SPL (90X)



146 dB peak SPL (10X), 138 dB peak SPL (90X)

Preexposure thresholds (dB SPL)

Animal\kHz	.125	.25	0.5	1.0	1.4	2.0	2.8	4.0	5.7	8.0
H47	26.0	8.4	-0.4	-0.6	-0.4	1.4	9.4	1.4	2.2	3.8
H61B	24.8	9.6	3.6	-2.4	3.4	1.6	4.8	-0.4	2.4	5.4
H153	25.6	9.0	-0.2	0.4	0.6	-0.4	1.0	0.4	2.6	3.8
H225	22.8	8.8	-0.4	1.2	-4.8	3.2	3.2	0.2	-0.2	2.6
J30	19.6	1.4	-1.0	1.4	-2.6	2.0	-1.0	0.2	0.6	-0.6
J36	25.8	5.4	-0.2	4.2	4.2	4.2	1.0	4.4	1.6	9.0
Mean	24.1	7.1	0.2	0.7	0.1	2.0	3.1	1.0	1.5	4.0
S.D.	2.5	3.2	1.7	2.2	3.4	1.6	3.7	1.8	1.1	3.2

Postexposure thresholds (dB SPL)

Animal\kHz	.125	.25	0.5	1.0	1.4	2.0	2.8	4.0	5.7	8.0
H47	31.8	34.9	27.1	32.4	32.9	38.4	33.2	34.7	35.0	34.8
H61B	29.1	24.6	21.1	20.6	11.9	30.6	37.8	21.1	16.4	21.9
H153	36.4	32.5	22.3	6.4	7.6	8.4	7.3	23.9	11.9	28.1
H225	29.6	25.8	26.4	23.7	19.7	14.4	21.2	10.4	15.6	8.9
J30	38.6	42.2	41.5	41.2	29.4	41.0	44.0	34.0	40.4	45.4
J36	28.6	38.4	33.8	41.0	40.7	42.2	56.0	44.4	44.1	55.0
Mean	32.3	33.1	28.7	27.5	23.7	29.2	33.2	28.1	27.2	32.3
S.D.	4.2	6.9	7.7	13.4	12.8	14.5	17.2	12.0	14.2	16.5

Permanent threshold shift (dB)

Animal\kHz	.125	.25	0.5	1.0	1.4	2.0	2.8	4.0	5.7	8.0
H47	5.8	26.5	27.5	33.0	33.3	37.0	23.8	33.3	32.8	31.0
H61B	4.3	15.0	17.5	23.0	8.5	29.0	33.0	21.5	14.0	16.5
H153	10.8	23.5	22.5	6.0	7.0	8.8	6.3	23.5	9.3	24.3
H225	6.8	17.0	26.8	22.5	24.5	11.3	18.0	10.3	15.8	6.3
J30	19.0	40.8	42.5	39.8	32.0	39.0	45.0	33.8	39.8	46.0
J36	2.8	33.0	34.0	36.8	36.5	38.0	55.0	40.0	42.5	46.0
Mean	8.2	26.0	28.5	26.8	23.6	27.2	30.2	27.0	25.7	28.3
S.D.	5.9	9.7	8.8	12.4	12.9	13.8	17.9	10.7	14.4	16.0

Temporary Threshold Shift (dB): 146 dB peak SPL (10X), 138 dB peak SPL (90X)

Frequency 0.125 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	8.0	37.0	22.0	26.0	28.0	35.0	33.0	24.0	11.0	14.0	8.0	9.0	5.0	7.0	12.0	-1.0	37.0
H61B	56.0	51.0	59.0	40.0	30.0	54.0	49.0	45.0	23.0	6.0	1.0	16.0	7.0	-1.0	4.0	7.0	59.0
H153	6.0	32.0	18.0	24.0	41.0	30.0	12.0	13.0	11.0	2.0	23.0	13.0	5.0	23.0	9.0	6.0	41.0
H225	49.0	36.0	27.0	35.0	38.0	51.0	49.0	23.0	11.0	7.0	17.0	13.0	6.0	7.0	7.0	7.0	51.0
J30	53.0	41.0	48.0	53.0	46.0	66.0	25.0	39.0	22.0	27.0	26.0	10.0	25.0	15.0	24.0	12.0	66.0
J36	18.0	51.0	49.0	38.0	52.0	38.0	13.0	43.0	21.0	21.0	14.0	13.0	4.0	-5.0	11.0	1.0	52.0
Mean	27.1	35.4	31.9	30.9	33.6	39.2	26.0	27.0	15.0	12.3	14.6	12.9	10.3	9.9	13.4	8.9	51.0
S.D.	24.5	17.2	20.9	16.6	17.0	21.2	18.7	16.2	6.8	8.9	8.5	2.7	8.5	11.0	8.7	10.3	10.8

Frequency 0.250 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	52.0	61.0	58.0	60.0	49.0	61.0	49.0	31.0	37.0	35.0	31.0	22.0	18.0	21.0	44.0	23.0	61.0
H61B	43.0	41.0	63.0	59.0	36.0	46.0	32.0	4.0	26.0	13.0	31.0	26.0	14.0	12.0	26.0	8.0	63.0
H153	37.0	37.0	59.0	41.0	55.0	41.0	35.0	20.0	18.0	27.0	28.0	20.0	25.0	27.0	20.0	22.0	59.0
H225	60.0	71.0	66.0	74.0	70.0	57.0	30.0	60.0	27.0	34.0	27.0	7.0	12.0	21.0	18.0	17.0	74.0
J30	60.0	67.0	55.0	80.0	71.0	68.0	59.0	67.0	51.0	75.0	49.0	22.0	48.0	41.0	39.0	35.0	80.0
J36	68.0	86.0	76.0	67.0	62.0	65.0	44.0	53.0	66.0	36.0	23.0	21.0	49.0	20.0	27.0	36.0	86.0
Mean	53.3	60.5	62.8	63.5	57.2	56.3	41.5	39.2	37.5	36.7	31.5	19.7	27.7	23.7	29.0	23.5	70.5
S.D.	11.7	18.6	7.5	13.7	13.4	10.7	11.3	24.8	18.0	20.7	9.1	6.5	16.7	9.8	10.4	10.7	11.1

Frequency 0.500 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	43.0	69.0	58.0	51.0	58.0	51.0	58.0	59.0	48.0	23.0	31.0	33.0	32.0	33.0	13.0	32.0	69.0
H61B	59.0	57.0	66.0	64.0	72.0	37.0	55.0	37.0	29.0	30.0	-2.0	31.0	14.0	5.0	24.0	27.0	72.0
H153	17.0	57.0	59.0	52.0	49.0	21.0	16.0	21.0	17.0	17.0	19.0	31.0	24.0	29.0	20.0	17.0	59.0
H225	71.0	59.0	71.0	63.0	46.0	73.0	53.0	78.0	9.0	26.0	34.0	29.0	28.0	30.0	28.0	21.0	78.0
J30	69.0	70.0	64.0	66.0	71.0	70.0	70.0	78.0	61.0	67.0	48.0	21.0	52.0	44.0	35.0	39.0	78.0
J36	64.0	53.0	64.0	63.0	86.0	91.0	88.0	83.0	52.0	42.0	49.0	49.0	36.0	46.0	32.0	22.0	91.0
Mean	53.8	60.8	63.7	59.8	63.7	57.2	56.7	59.3	36.0	34.2	29.8	32.3	31.0	31.2	25.3	26.3	74.5
S.D.	20.6	7.0	4.8	6.6	15.4	25.7	23.8	25.4	20.8	18.1	19.2	9.2	12.8	14.7	8.1	8.1	10.7

Temporary Threshold Shift (dB): 146 dB peak SPL (10X), 138 dB peak SPL (90X)

Frequency 1.000 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	50.0	58.0	65.0	63.0	23.0	58.0	65.0	60.0	49.0	32.0	43.0	38.0	35.0	29.0	34.0	34.0	65.0
H61B	44.0	52.0	68.0	65.0	80.0	72.0	70.0	59.0	45.0	14.0	28.0	34.0	19.0	19.0	24.0	30.0	80.0
H153	31.0	43.0	43.0	56.0	67.0	35.0	2.0	4.0	3.0	13.0	13.0	24.0	8.0	-1.0	6.0	11.0	67.0
H225	47.0	47.0	67.0	67.0	58.0	60.0	52.0	45.0	39.0	17.0	20.0	31.0	35.0	9.0	19.0	27.0	67.0
J30	51.0	57.0	53.0	65.0	68.0	67.0	70.0	78.0	42.0	65.0	50.0	9.0	60.0	35.0	43.0	21.0	78.0
J36	54.0	53.0	97.0	65.0	90.0	54.0	80.0	68.0	52.0	52.0	42.0	24.0	45.0	36.0	34.0	32.0	97.0
Mean	46.2	51.7	65.5	63.5	64.3	57.7	56.5	52.3	38.3	32.2	32.7	26.7	33.7	21.2	26.7	25.8	75.7
S.D.	8.2	5.8	18.2	3.9	23.1	12.8	28.2	26.3	17.9	21.9	14.6	10.3	18.4	14.9	13.2	8.6	12.2

Frequency 1 400 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	51.0	50.0	59.0	52.0	81.0	62.0	72.0	60.0	49.0	52.0	50.0	52.0	31.0	29.0	43.0	30.0	81.0
H61B	69.0	62.0	53.0	68.0	70.0	47.0	68.0	14.0	15.0	49.0	44.0	2.0	15.0	6.0	7.0	6.0	70.0
H153	16.0	40.0	58.0	56.0	57.0	29.0	4.0	8.0	4.0	10.0	1.0	1.0	0.0	18.0	4.0	6.0	58.0
H225	83.0	74.0	72.0	63.0	78.0	82.0	57.0	54.0	14.0	25.0	5.0	21.0	22.0	25.0	19.0	32.0	83.0
J30	76.0	61.0	46.0	61.0	71.0	69.0	73.0	70.0	46.0	58.0	65.0	23.0	53.0	20.0	38.0	17.0	76.0
J36	40.0	79.0	74.0	64.0	78.0	50.0	68.0	39.0	48.0	28.0	58.0	48.0	31.0	42.0	45.0	28.0	79.0
Mean	55.8	61.0	60.3	60.7	72.5	56.5	57.0	40.8	29.3	37.0	37.2	24.5	25.3	23.3	26.0	19.8	74.5
S.D.	25.2	14.5	10.9	5.8	8.7	18.6	26.6	25.3	20.5	18.8	27.4	21.8	17.8	12.0	18.4	11.9	9.3

Frequency 2.000 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	48.0	59.0	18.0	55.0	68.0	71.0	49.0	48.0	37.0	37.0	36.0	31.0	38.0	33.0	46.0	31.0	71.0
H61B	62.0	66.0	66.0	47.0	60.0	58.0	58.0	59.0	58.0	22.0	51.0	40.0	26.0	14.0	29.0	47.0	66.0
H153	11.0	59.0	63.0	62.0	36.0	35.0	37.0	11.0	2.0	19.0	20.0	7.0	9.0	4.0	11.0	11.0	63.0
H225	40.0	71.0	59.0	54.0	52.0	68.0	61.0	42.0	16.0	4.0	17.0	0.0	4.0	12.0	10.0	19.0	71.0
J30	64.0	66.0	41.0	62.0	70.0	77.0	56.0	62.0	54.0	62.0	63.0	32.0	38.0	37.0	50.0	31.0	77.0
J36	64.0	68.0	72.0	51.0	87.0	73.0	73.0	51.0	52.0	52.0	37.0	46.0	44.0	16.0	50.0	42.0	87.0
Mean	48.2	64.8	53.2	55.2	62.2	63.7	55.7	45.5	36.5	32.7	37.3	26.0	26.5	19.3	32.7	30.2	72.5
S.D.	20.7	4.9	20.2	6.0	17.3	15.4	12.1	18.4	22.9	21.8	17.7	18.4	16.6	12.9	18.8	13.5	8.6

Temporary Threshold Shift (dB): 146 dB peak SPL (10X), 138 dB peak SPL (90X)

Frequency 2.800 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	48.0	39.0	36.0	54.0	61.0	69.0	47.0	27.0	47.0	28.0	29.0	24.0	21.0	24.0	36.0	14.0	69.0
H61B	44.0	54.0	68.0	61.0	68.0	59.0	45.0	39.0	41.0	33.0	34.0	41.0	33.0	14.0	40.0	45.0	68.0
H153	40.0	56.0	62.0	58.0	54.0	25.0	8.0	19.0	22.0	46.0	7.0	8.0	3.0	6.0	10.0	6.0	62.0
H225	49.0	67.0	58.0	43.0	51.0	56.0	68.0	48.0	10.0	23.0	21.0	1.0	11.0	15.0	6.0	40.0	68.0
J30	62.0	57.0	72.0	68.0	70.0	73.0	37.0	74.0	31.0	61.0	61.0	50.0	55.0	57.0	39.0	29.0	74.0
J36	65.0	52.0	62.0	54.0	56.0	81.0	55.0	55.0	63.0	53.0	40.0	39.0	46.0	47.0	54.0	73.0	81.0
Mean	51.3	54.2	59.7	56.3	60.0	60.5	43.3	43.7	35.7	40.7	32.0	27.2	28.2	27.2	30.8	34.5	70.3
S.D.	10.0	9.1	12.6	8.4	7.7	19.7	20.2	19.9	18.8	15.0	18.2	19.6	20.2	20.3	18.8	24.0	6.5

Frequency 4.000 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	43.0	52.0	55.0	66.0	73.0	58.0	46.0	41.0	40.0	35.0	32.0	34.0	32.0	30.0	47.0	24.0	73.0
H61B	44.0	51.0	54.0	62.0	69.0	47.0	44.0	28.0	34.0	27.0	40.0	-2.0	33.0	8.0	6.0	39.0	69.0
H153	32.0	56.0	54.0	60.0	57.0	16.0	30.0	17.0	14.0	6.0	7.0	1.0	17.0	37.0	18.0	22.0	60.0
H225	44.0	52.0	67.0	54.0	57.0	62.0	54.0	36.0	8.0	7.0	6.0	-3.0	4.0	1.0	8.0	28.0	67.0
J30	41.0	55.0	61.0	60.0	57.0	64.0	59.0	75.0	46.0	52.0	43.0	44.0	45.0	42.0	20.0	28.0	75.0
J36	65.0	63.0	48.0	47.0	65.0	67.0	41.0	43.0	33.0	43.0	40.0	36.0	36.0	47.0	44.0	33.0	67.0
Mean	44.8	54.8	56.5	58.2	63.0	52.3	45.7	40.0	29.2	28.3	28.0	18.3	27.8	27.5	23.8	29.0	68.5
S.D.	10.9	4.4	6.6	6.7	7.0	19.1	10.2	19.[illegible]	14.9	18.8	17.1	21.8	14.8	18.8	17.7	6.2	5.3

Frequency 5.700 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	31.0	56.0	43.0	65.0	64.0	64.0	62.0	52.0	60.0	41.0	30.0	21.0	30.0	31.0	49.0	21.0	65.0
H61B	36.0	38.0	55.0	53.0	80.0	60.0	54.0	23.0	40.0	46.0	39.0	30.0	17.0	10.0	19.0	10.0	80.0
H153	22.0	40.0	54.0	52.0	56.0	6.0	0.0	23.0	30.0	40.0	11.0	14.0	10.0	10.0	8.0	9.0	56.0
H225	20.0	56.0	60.0	50.0	72.0	69.0	69.0	1.0	19.0	6.0	17.0	-3.0	15.0	13.0	13.0	22.0	72.0
J30	65.0	61.0	65.0	64.0	68.0	68.0	41.0	61.0	53.0	39.0	49.0	37.0	52.0	48.0	31.0	28.0	68.0
J36	71.0	50.0	59.0	55.0	81.0	50.0	52.0	50.0	38.0	38.0	35.0	31.0	41.0	42.0	39.0	48.0	81.0
Mean	40.8	50.2	56.0	56.5	70.2	52.8	46.3	35.0	40.0	35.0	30.2	21.7	27.5	25.7	26.5	23.0	70.3
S.D.	21.9	9.3	7.5	6.4	9.6	24.0	24.6	23.0	14.9	14.5	14.1	14.6	16.5	17.0	15.9	14.3	9.5

Temporary Threshold Shift (dB): 146 cB peak SPL (10X), 138 dB peak SPL (90X)

Frequency 8.000 kHz

Animal\day	0.	.021	.042	.063	.125	.25	1.	2.	6.	9.	13.	16.	20.	23.	27.	30.	Max
H47	36.0	55.0	62.0	53.0	61.0	37.0	55.0	44.0	57.0	39.0	27.0	45.0	27.0	25.0	47.0	25.0	62.0
H61B	45.0	60.0	43.0	57.0	65.0	54.0	50.0	4.0	35.0	52.0	26.0	44.0	34.0	5.0	13.0	14.0	65.0
H153	12.0	54.0	54.0	55.0	52.0	36.0	17.0	23.0	26.0	44.0	45.0	49.0	23.0	34.0	28.0	12.0	55.0
H225	26.0	24.0	65.0	59.0	45.0	81.0	26.0	2.0	-4.0	12.0	15.0	1.0	2.0	6.0	11.0	6.0	81.0
J30	58.0	63.0	74.0	80.0	77.0	36.0	59.0	75.0	40.0	63.0	65.0	41.0	63.0	50.0	51.0	20.0	80.0
J36	74.0	52.0	61.0	63.0	60.0	64.0	53.0	44.0	42.0	22.0	29.0	40.0	45.0	66.0	31.0	42.0	74.0
Mean	41.8	51.3	59.8	61.2	60.0	51.3	43.3	32.0	32.7	38.7	34.5	36.7	32.3	31.0	30.2	19.8	69.5
S.D.	22.3	14.0	10.5	9.8	11.0	18.6	17.4	27.9	20.6	18.9	17.8	17.8	20.7	24.2	16.6	12.7	10.5

Summary of Group Anatomical Data with

Cochleograms and PTS Audiograms

for Individual Animals

146 dB peak SPL (10X), 138 dB peak SPL (90X)

Total number of cochlear sensory cells missing

Animal number	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Total outer hair cells
H47	30	1783	1855	1703	5341
H61B	110	2367	2249	2198	6814
H153	6	337	191	116	644
H225	139	1241	1155	983	3379
J30	398	2137	2009	1827	5973
J36	909	1836	1806	1716	5358
Group mean	265				4585
S.D.	345				2238
S.E.	141				914

Total sensory cell losses over octave band lengths of the cochlea centered at the frequencies indicated

	Octave band center frequency	Inner hair cells	Outer hair cells
Group means			
	0.125 kHz	1.5	155.0
	0.25 kHz	4.7	256.2
	0.5 kHz	3.5	630.7
	1 kHz	40.5	856.2
	2 kHz	62.2	855.5
	4 kHz	51.2	824.5
	8 kHz	52.8	555.2
	16 kHz	49.0	451.7
Standard deviations			
	0.125 kHz	3.2	105.3
	0.25 kHz	5.7	268.2
	0.5 kHz	3.9	403.7
	1 kHz	55.7	237.0
	2 kHz	58.7	410.3
	4 kHz	78.0	407.4
	8 kHz	102.0	483.2
	16 kHz	92.3	477.5

146 dB peak SPL (10X), 138 dB peak SPL (90X)

Total sensory cell losses over octave band frequencies

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Chinchilla H47							
0.125 kHz	0	92	132	98	322	6	18
0.25 kHz	3	180	141	138	459	1	0
0.5 kHz	2	381	383	295	1059	1	10
1 kHz	2	363	363	353	1079	2	18
2 kHz	3	373	373	362	1108	0	14
4 kHz	8	351	371	370	1092	24	61
8 kHz	5	27	81	77	185	0	0
16 kHz	7	16	11	10	37	0	1
TOTALS	30	1783	1855	1703	5341	34	122
Chinchilla H61B							
0.125 kHz	0	79	63	75	217	0	0
0.25 kHz	3	301	206	183	690	0	1
0.5 kHz	0	347	341	318	1006	0	20
1 kHz	4	329	329	325	983	0	23
2 kHz	40	337	337	334	1008	29	79
4 kHz	44	337	337	337	1011	31	65
8 kHz	17	337	337	330	1004	26	34
16 kHz	2	300	299	296	895	0	8
TOTALS	110	2367	2249	2198	6814	86	230
Chinchilla H153							
0.125 kHz	1	9	23	27	59	0	0
0.25 kHz	3	4	6	13	23	0	0
0.5 kHz	1	14	7	3	24	0	0
1 kHz	0	271	96	42	409	2	4
2 kHz	1	7	5	12	24	0	0
4 kHz	0	2	1	4	7	0	0
8 kHz	0	27	52	15	94	0	0
16 kHz	0	3	1	0	4	0	0
TOTALS	6	337	191	116	644	2	4

146 dB peak SPL (10X), 138 dB peak SPL (90X)

Total sensory cell losses over octave band frequencies

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Chinchilla H225							
0.125 kHz	8	29	43	54	126	0	0
0.25 kHz	3	8	12	11	31	0	0
0.5 kHz	3	238	135	56	429	2	12
1 kHz	16	343	328	146	817	2	19
2 kHz	71	353	352	335	1040	51	66
4 kHz	32	254	275	332	861	70	102
8 kHz	6	10	9	49	68	0	0
16 kHz	0	6	1	0	7	0	0
TOTALS	139	1241	1155	983	3379	125	199
Chinchilla J30							
0.125 kHz	0	4	16	19	39	0	0
0.25 kHz	16	158	66	11	235	1	0
0.5 kHz	11	338	292	205	835	25	3
1 kHz	129	329	327	315	971	346	200
2 kHz	145	336	336	309	981	360	141
4 kHz	16	336	336	332	1004	32	26
8 kHz	29	336	336	336	1008	5	21
16 kHz	52	300	300	300	900	34	13
TOTALS	398	2137	2009	1827	5973	803	404
Chinchilla J36							
0.125 kHz	0	20	65	82	167	0	0
0.25 kHz	0	12	15	72	99	1	0
0.5 kHz	4	227	151	53	431	4	2
1 kHz	92	316	314	248	878	185	150
2 kHz	113	324	324	324	972	255	244
4 kHz	207	324	324	324	972	421	279
8 kHz	260	324	324	324	972	516	324
16 kHz	233	289	289	289	867	467	289
TOTALS	909	1836	1806	1716	5358	1849	1288

146 dB peak SPL (10X), 138 dB peak SPL (90X)

Total sensory cell losses over octave band frequencies

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Group means							
0.125 kHz	1.5	38.8	57.0	59.2	155.0	1.0	3.0
0.25 kHz	4.7	110.5	74.3	71.3	256.2	0.5	0.2
0.5 kHz	3.5	257.5	218.2	155.0	630.7	5.3	7.8
1 kHz	40.5	325.2	292.8	238.2	856.2	89.5	69.0
2 kHz	62.2	288.3	287.8	279.3	855.5	115.8	90.7
4 kHz	51.2	267.3	274.0	283.2	824.5	96.3	88.8
8 kHz	52.8	176.8	189.8	188.5	555.2	91.2	63.2
16 kHz	49.0	152.3	150.2	149.2	451.7	83.5	51.8
TOTALS	265.3	1616.8	1544.2	1423.8	4584.8	483.2	374.5
Group standard deviations							
0.125 kHz	3.2	37.4	41.9	31.5	105.3	2.4	7.3
0.25 kHz	5.7	122.4	82.4	74.3	268.2	0.5	0.4
0.5 kHz	3.9	134.4	144.0	135.6	403.7	9.8	7.6
1 kHz	55.7	31.0	97.8	121.4	237.0	145.5	83.9
2 kHz	58.7	138.9	139.6	132.1	410.3	153.3	90.4
4 kHz	78.0	134.4	137.3	137.7	407.4	160.6	99.5
8 kHz	102.0	170.5	157.8	156.3	483.2	208.4	128.6
16 kHz	92.3	157.9	159.8	159.8	477.5	188.4	116.3
TOTALS	344.9	733.2	756.4	752.3	2238.3	733.1	466.5

146 dB peak SPL (10X), 138 dB peak SPL (90X)

Percent sensory cell losses over octave band frequencies

Chinchilla H47

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
0.125 kHz	0.0	42.0	60.3	44.7	49.0	1.8	8.2
0.25 kHz	1.0	46.9	36.7	35.9	39.8	0.2	0.0
0.5 kHz	0.7	99.5	100.0	77.0	92.2	0.2	2.6
1 kHz	0.7	99.7	99.7	97.0	98.8	0.3	4.9
2 kHz	1.1	100.0	100.0	97.1	99.0	0.0	3.8
4 kHz	2.7	94.4	99.7	99.5	97.9	4.0	16.4
8 kHz	1.7	7.3	21.8	20.7	16.6	0.0	0.0
16 kHz	2.6	4.8	3.3	3.0	3.7	0.0	0.3

Chinchilla H61B

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
0.125 kHz	0.0	39.9	31.8	37.9	36.5	0.0	0.0
0.25 kHz	1.1	86.7	59.4	52.7	66.3	0.0	0.3
0.5 kHz	0.0	100.0	98.3	91.6	96.6	0.0	5.8
1 kHz	1.6	100.0	100.0	98.8	99.6	0.0	7.0
2 kHz	15.9	100.0	100.0	99.1	99.7	5.3	23.4
4 kHz	16.7	100.0	100.0	100.0	100.0	5.7	19.3
8 kHz	6.3	100.0	100.0	97.9	99.3	4.8	10.1
16 kHz	0.8	99.7	99.3	98.3	99.1	0.0	2.7

Chinchilla H153

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
0.125 kHz	0.6	4.4	11.2	13.2	9.6	0.0	0.0
0.25 kHz	1.1	1.1	1.7	3.6	2.1	0.0	0.0
0.5 kHz	0.4	3.9	1.9	0.8	2.2	0.0	0.0
1 kHz	0.0	79.2	28.1	12.3	39.9	0.4	1.2
2 kHz	0.4	2.0	1.4	3.4	2.3	0.0	0.0
4 kHz	0.0	0.6	0.3	1.1	0.7	0.0	0.0
8 kHz	0.0	7.7	14.9	4.3	9.0	0.0	0.0
16 kHz	0.0	1.0	0.3	0.0	0.4	0.0	0.0

146 dB peak SPL (10X), 138 dB peak SPL (90X)

Percent sensory cell losses over octave band frequencies

Chinchilla H225

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
0.125 kHz	5.1	14.0	20.8	26.1	20.3	0.0	0.0
0.25 kHz	1.1	2.2	3.3	3.0	2.8	0.0	0.0
0.5 kHz	1.1	65.6	37.2	15.4	39.4	0.4	3.3
1 kHz	6.0	99.4	95.1	42.3	78.9	0.4	5.5
2 kHz	26.9	100.0	99.7	94.9	98.2	9.0	18.7
4 kHz	11.7	72.2	78.1	94.3	81.5	12.3	29.0
8 kHz	2.1	2.8	2.5	13.9	6.4	0.0	0.0
16 kHz	0.0	1.9	0.3	0.0	0.7	0.0	0.0

Chinchilla J30

	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
0.125 kHz	0.0	2.0	8.1	9.6	6.6	0.0	0.0
0.25 kHz	6.1	45.5	19.0	3.2	22.6	0.2	0.0
0.5 kHz	4.2	98.0	84.6	59.4	80.7	4.6	0.9
1 kHz	50.6	100.0	99.4	95.7	98.4	65.2	60.8
2 kHz	57.8	100.0	100.0	92.0	97.3	66.4	42.0
4 kHz	6.1	100.0	100.0	98.8	99.6	5.9	7.7
8 kHz	10.7	100.0	100.0	100.0	100.0	0.9	6.3
16 kHz	21.5	100.0	100.0	100.0	100.0	7.0	4.3

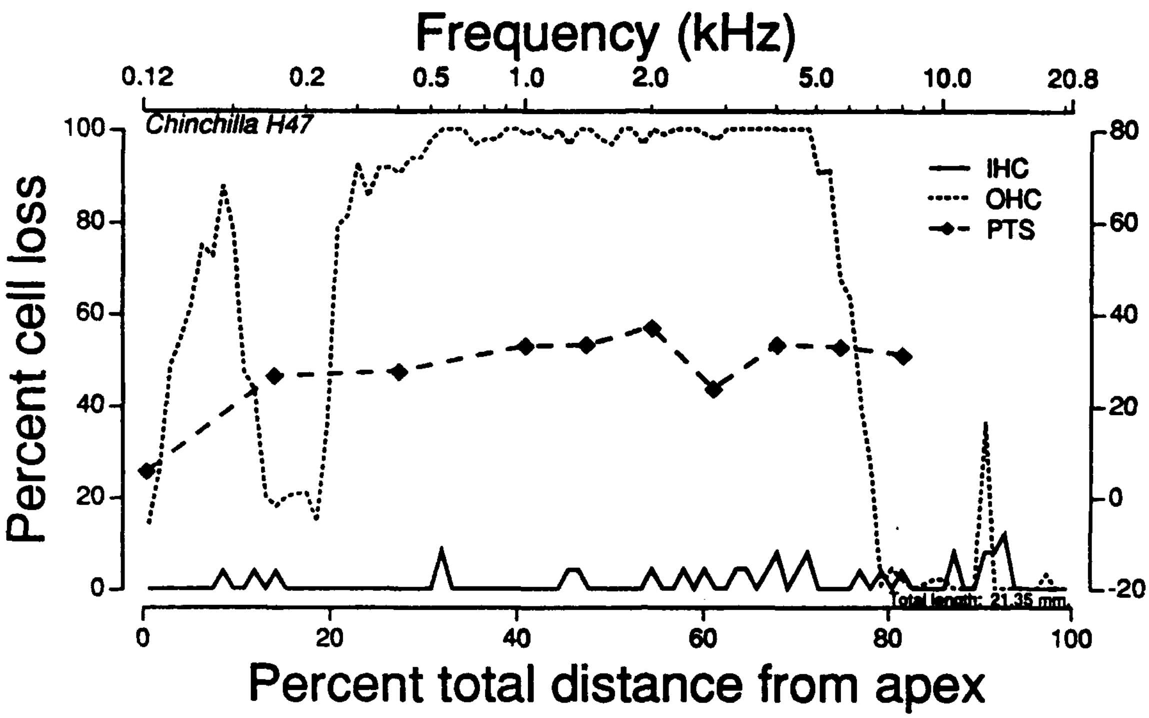
Chinchilla J36

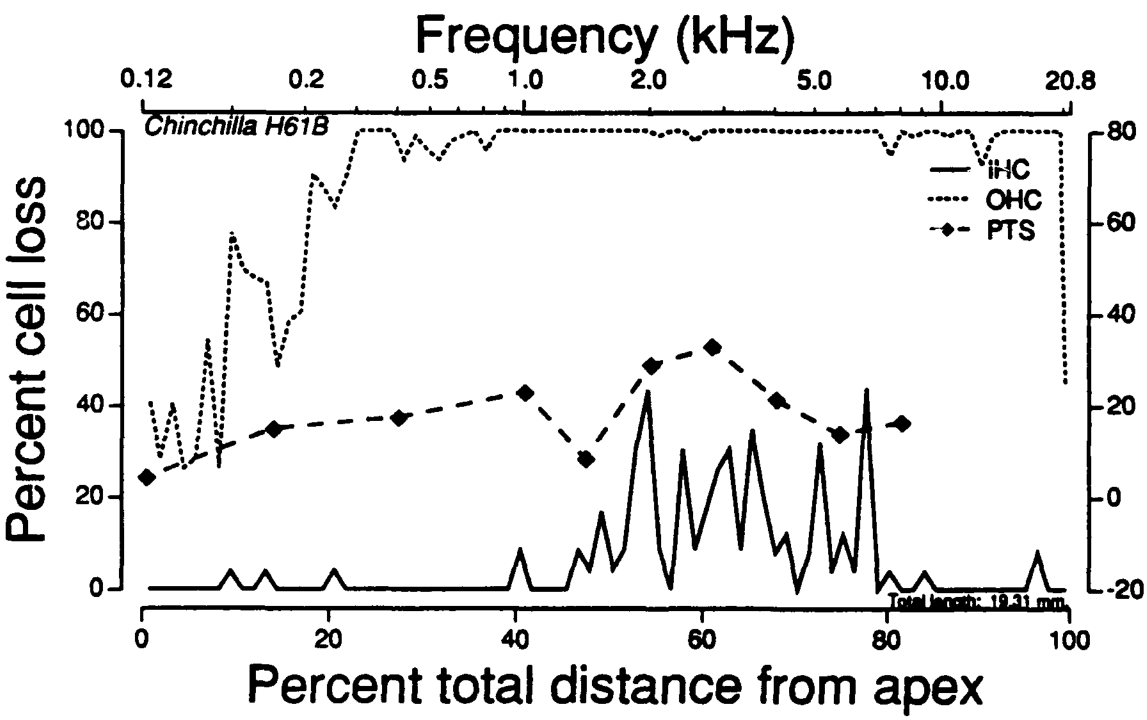
	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
0.125 kHz	0.0	10.5	34.2	43.2	29.3	0.0	0.0
0.25 kHz	0.0	3.6	4.5	21.6	9.9	0.2	0.0
0.5 kHz	1.6	68.2	45.3	15.9	43.1	0.8	0.6
1 kHz	37.6	99.7	99.1	78.2	92.3	36.1	47.3
2 kHz	46.7	100.0	100.0	100.0	100.0	48.9	75.3
4 kHz	81.8	100.0	100.0	100.0	100.0	80.5	86.1
8 kHz	99.6	100.0	100.0	100.0	100.0	98.9	100.0
16 kHz	99.6	100.0	100.0	100.0	100.0	100.0	100.0

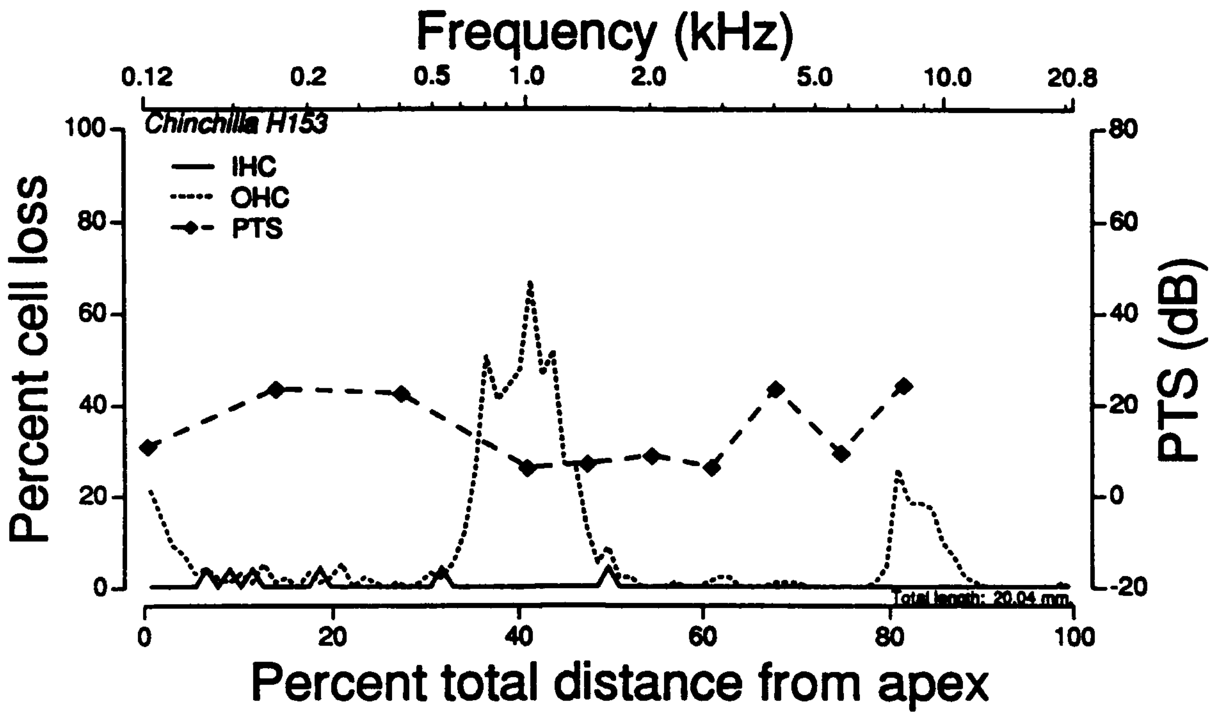
146 dB peak SPL (10X), 138 dB peak SPL (90X)

Percent sensory cell losses over octave band frequencies

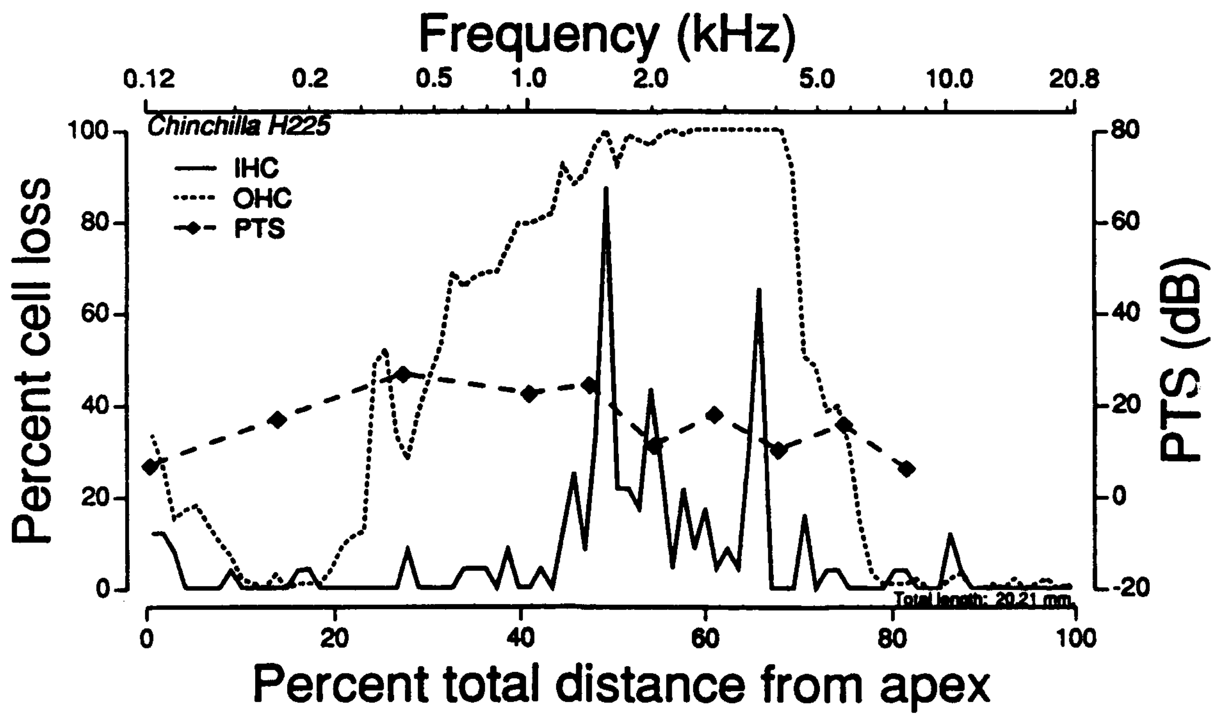
	Inner hair cells	1st row outer hair cells	2nd row outer hair cells	3rd row outer hair cells	Comb. outer hair cells	Inner pillar cells	Outer pillar cells
Group means							
0.125 kHz	0.95	18.80	27.73	29.12	25.22	0.30	1.37
0.25 kHz	1.73	31.00	20.77	20.00	23.92	0.10	0.05
0.5 kHz	1.33	72.53	61.22	43.35	59.03	1.00	2.20
1 kHz	16.08	96.33	86.90	70.72	84.65	17.07	21.12
2 kHz	24.80	83.67	83.52	81.08	82.76	21.60	27.20
4 kHz	19.83	77.87	79.68	82.28	79.94	18.07	26.42
8 kHz	20.07	52.97	56.53	56.13	55.21	17.43	19.40
16 kHz	20.75	51.23	50.53	50.22	50.66	17.83	17.88
Group standard deviations							
0.125 kHz	2.05	17.63	19.11	15.24	16.29	0.73	3.35
0.25 kHz	2.18	34.76	23.16	20.81	25.16	0.11	0.12
0.5 kHz	1.51	37.17	39.43	37.59	37.01	1.79	2.16
1 kHz	22.19	8.40	28.86	35.72	23.28	27.59	25.94
2 kHz	23.70	40.01	40.23	38.17	39.44	28.67	27.95
4 kHz	30.96	39.36	39.86	39.83	39.50	30.84	30.88
8 kHz	39.16	51.55	48.02	47.58	48.92	39.95	39.71
16 kHz	39.51	53.33	53.94	53.93	53.73	40.35	40.27


Frequency (kHz)
0.12
0.2
0.5
1.0
2.0
5.0
10.0
20.8
Chinchilla H47
IHC
OHC
PTS
Percent cell loss
PTS (dB)
Total length: 21.35 mm
Percent total distance from apex

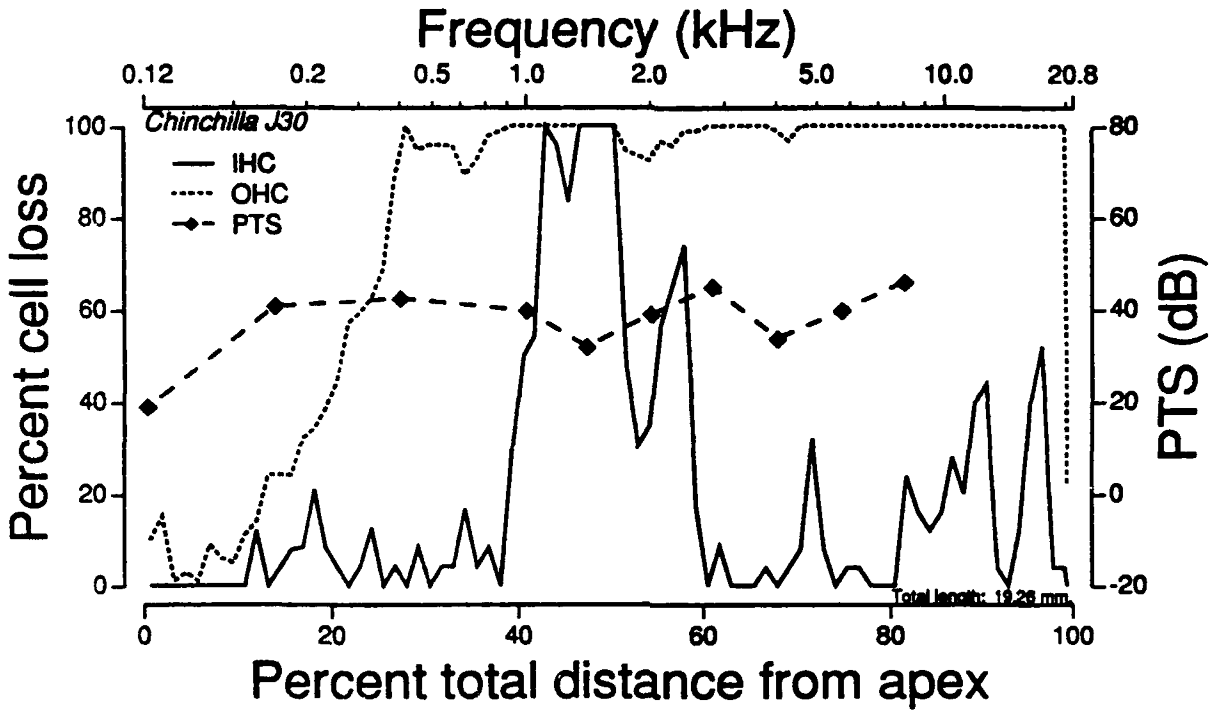

Frequency (kHz)
0.12
0.2
0.5
1.0
2.0
5.0
10.0
20.8
Chinchilla H61B
IHC
OHC
PTS
Percent cell loss
PTS (dB)
Total length: 19.31 mm
Percent total distance from apex

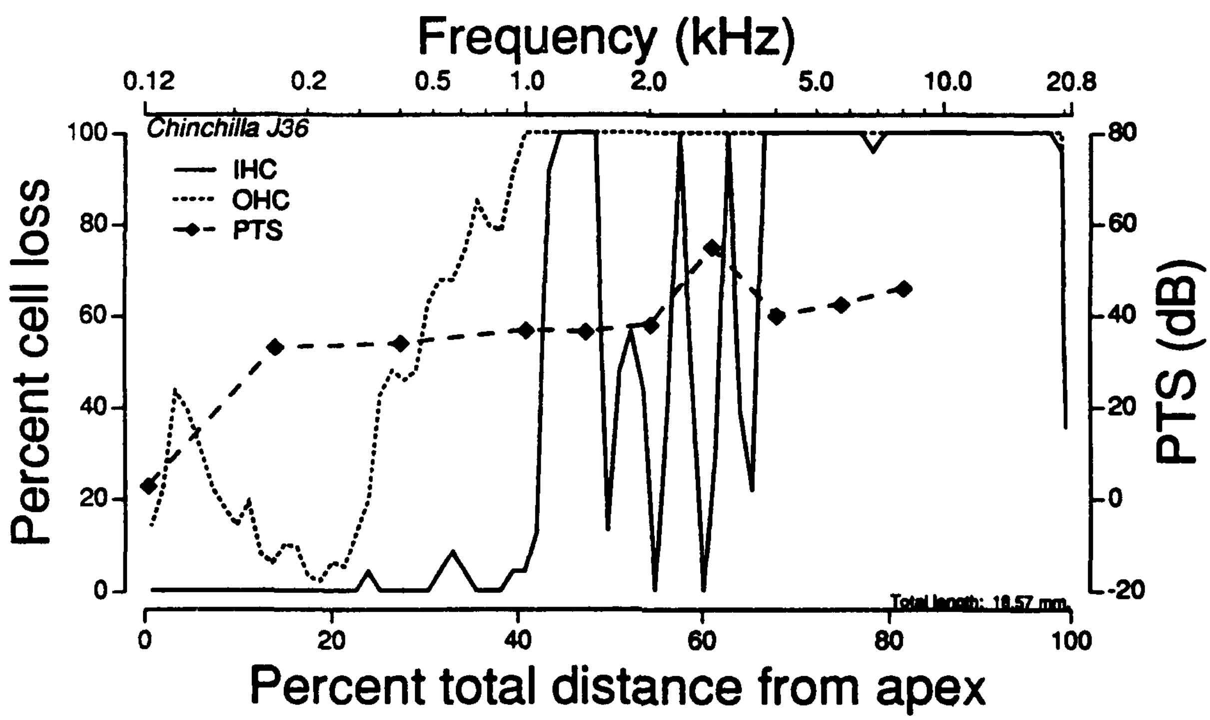


Frequency (kHz)
0.12 0.2 0.5 1.0 2.0 5.0 10.0 20.8
Chinchilla H153
IHC
OHC
PTS
Percent cell loss
PTS (dB)
Total length: 20.04 mm
Percent total distance from apex



Frequency (kHz)
0.12 0.2 0.5 1.0 2.0 5.0 10.0 20.8
Chinchilla H225
IHC
OHC
PTS
Percent cell loss
PTS (dB)
Total length: 20.21 mm
Percent total distance from apex


Frequency (kHz)
0.12
0.2
0.5
1.0
2.0
5.0
10.0
20.8
Chinchilla J30
IHC
OHC
PTS
Percent cell loss
PTS (dB)
Total length: 19.26 mm
Percent total distance from apex


Frequency (kHz)
0.12
0.2
0.5
1.0
2.0
5.0
10.0
20.8
Chinchilla J36
IHC
OHC
PTS
Percent cell loss
PTS (dB)
Total length: 18.57 mm
Percent total distance from apex

Initial distribution

Commander, U.S. Army Natick Research,
Development and Evaluation Center
ATTN: STRNC-MIL (Documents Librarian)
Natick, MA 01760-5040

Naval Submarine Medical
Research Laboratory
Medical Library, Naval Sub Base
Box 900
Groton, CT 06340

Commander/Director
U.S. Army Combat Surveillance
and Target Acquisition Lab
ATTN: DELCS-D
Fort Monmouth, NJ 07703-5304

Commander
10th Medical Laboratory
ATTN: Audiologist
APO New York 09180

Naval Air Development Center
Technical Information Division
Technical Support Detachment
Warminster, PA 18974

Commanding Officer, Naval Medical
Research and Development Command
National Naval Medical Center
Bethesda, MD 20814-5044

Deputy Director, Defense Research
and Engineering
ATTN: Military Assistant
for Medical and Life Sciences
Washington, DC 20301-3080

Commander, U.S. Army Research
Institute of Environmental Medicine
Natick, MA 01760

U.S. Army Avionics Research
and Development Activity
ATTN: SAVAA-P-TP
Fort Monmouth, NJ 07703-5401

U.S. Army Communications-Electronics
Command
ATTN: AMSEL-RD-ESA-D
Fort Monmouth, NJ 07703

Library
Naval Submarine Medical Research Lab
Box 900, Naval Sub Base
Groton, CT 06349-5900

Commander
Man-Machine Integration System
Code 602
Naval Air Development Center
Warminster, PA 18974

Commander
Naval Air Development Center
ATTN: Code 602-B (Mr. Brindle)
Warminster, PA 18974

Commanding Officer
Harry G. Armstrong Aerospace
Medical Research Laboratory
Wright-Patterson
Air Force Base, OH 45433

Director
Army Audiology and Speech Center
Walter Reed Army Medical Center
Washington, DC 20307-5001

Commander, U.S. Army Institute
of Dental Research
ATTN: Jean A. Setterstrom, Ph. D.
Walter Reed Army Medical Center
Washington, DC 20307-5300

Naval Air Systems Command
Technical Air Library 950D
Room 278, Jefferson Plaza II
Department of the Navy
Washington, DC 20361

U.S. Army Training
and Doctrine Command
ATTN: Surgeon
Fort Monroe, VA 23651-5000

Director, U.S. Army Human
Engineering Laboratory
ATTN: Technical Library
Aberdeen Proving Ground, MD 21005

Commander, U.S. Army Test
and Evaluation Command
ATTN: AMSTE-AD-H
Aberdeen Proving Ground, MD 21005

Director
U.S. Army Ballistic
Research Laboratory
ATTN: DRXBR-OD-ST Tech Reports
Aberdeen Proving Ground, MD 21005

Commander
U.S. Army Medical Research
Institute of Chemical Defense
ATTN: SGRD-UV-AO
Aberdeen Proving Ground,
MD 21010-5425

Commander, U.S. Army Medical
Research and Development Command
ATTN: SGRD-RMS (Ms. Madigan)
Fort Detrick, Frederick, MD 21702-5012

Director
Walter Reed Army Institute of Research
Washington, DC 20307-5100

HQ DA (DASG-PSP-O)
5109 Leesburg Pike
Falls Church, VA 22041-3258

Harry Diamond Laboratories
ATTN: Technical Information Branch
2800 Powder Mill Road
Adelphi, MD 20783-1197

U.S. Army Materiel Systems
Analysis Agency
ATTN: AMXSY-PA (Reports Processing)
Aberdeen Proving Ground
MD 21005-5071

U.S. Army Ordnance Center
and School Library
Simpson Hall, Building 3071
Aberdeen Proving Ground, MD 21005

U.S. Army Environmental
Hygiene Agency
Building E2100
Aberdeen Proving Ground, MD 21010

Technical Library Chemical Research
and Development Center
Aberdeen Proving Ground, MD
21010--5423

Commander
U.S. Army Medical Research
Institute of Infectious Disease
SGRD-UIZ-C
Fort Detrick, Frederick, MD 21702

Director, Biological
Sciences Division
Office of Naval Research
600 North Quincy Street
Arlington, VA 22217

Commander
U.S. Army Materiel Command
ATTN: AMCDE-XS
5001 Eisenhower Avenue
Alexandria, VA 22333

Commandant
U.S. Army Aviation
Logistics School ATTN: ATSQ-TDN
Fort Eustis, VA 23604

Headquarters (ATMD)
U.S. Army Training
and Doctrine Command
Fort Monroe, VA 23651

Structures Laboratory Library
USARTL-AVSCOM
NASA Langley Research Center
Mail Stop 266
Hampton, VA 23665

Naval Aerospace Medical
Institute Library
Building 1953, Code 03L
Pensacola, FL 32508-5600

Command Surgeon
HQ USCENTCOM (CCSG)
U.S. Central Command
MacDill Air Force Base FL 33608

Air University Library
(AUL/LSE)
Maxwell Air Fore Base, AL 36112

U.S. Air Force Institute
of Technology (AFIT/LDEE)
Building 640, Area B
Wright-Patterson
Air Force Base, OH 45433

Henry L. Taylor
Director, Institute of Aviation
University of Illinois-Willard Airport
Savoy, IL 61874

Chief, Nation Guard Bureau
ATTN: NGB-ARS (COL Urbauer)
Room 410, Park Center 4
4501 Ford Avenue
Alexandria, VA 22302-1451

Commander
U.S. Army Aviation Systems Command
ATTN: SGRD-UAX-AL (MAJ Gillette)
4300 Goodfellow Blvd., Building 105
St. Louis, MO 63120

U.S. Army Aviation Systems Command
Library and Information Center Branch
ATTN: AMSAV-DIL
4300 Goodfe'low Boulevard
St. Louis, MO 63120

Federal Aviation Administration
Civil Aeromedical Institute
Library AAM-400A
P.O. Box 25082
Oklahoma City, OK 73125

Commander
U.S. Army Academy
of Health Sciences
ATTN: Library
Fort Sam Houston, TX 78234

Commander
U.S. Army Institute of Surgical Research
ATTN: SGRD-USM (Jan Duke)
Fort Sam Houston, TX 78234-6200

AAMRL/HEX
Wright-Patterson
Air Force Base, OH 45433

John A. Dellinger,
Southwest Research Institute
P. 0. Box 28510
San Antonio, TX 78284

Product Manager
Aviation Life Support Equipment
ATTN: AMCPM-ALSE
4300 Goodfellow Boulevard
St. Louis, MO 63120-1798

Commander
U.S. Army Aviation
Systems Command
ATTN: AMSAV-ED
4300 Goodfellow Boulevard
St. Louis, MO 63120

Commanding Officer
Naval Biodynamics Laboratory
P.O. Box 24907
New Orleans, LA 70189-0407

Assistant Commandant
U.S. Army Field Artillery School
ATTN: Morris Swott Technical Library
Fort Sill, OK 73503-0312

Commander
U.S. Army Health Services Command
ATTN: HSOP-SO
Fort Sam Houston, TX 78234-6000

HQ USAF/SGPT
Bolling Air Force Base, DC 20332-6188

U.S. Army Dugway Proving Ground
Technical Library, Building 5330
Dugway, UT 84022

U.S. Army Yuma Proving Ground
Technical Library
Yuma, AZ 85364

AFFTC Technical Library
6510 TW/TSTL
Edwards Air Force Base,
CA 93523-5000

Commander
Code 3431
Naval Weapons Center
China Lake, CA 93555

Aeromechanics Laboratory
U.S. Army Research and Technical Labs
Ames Research Center, M/S 215-1
Moffett Field, CA 94035

Sixth U.S. Army
ATTN: SMA
Presidio of San Francisco, CA 94129

Commander
U.S. Army Aeromedical Center
Fort Rucker, AL 36362

U.S. Air Force School
of Aerospace Medicine
Strughold Aeromedical Library Technical
Reports Section (TSKD)
Brooks Air Force Base, TX 78235-5301

Dr. Diane Damos
Department of Human Factors
ISSM, USC
Los Angeles, CA 90089-0021

U.S. Army White Sands
Missile Range
ATTN: STEWS-IM-ST
White Sands Missile Range, NM 88002

U.S. Army Aviation Engineering
Flight Activity
ATTN: SAVTE-M (Tech Lib) Stop 217
Edwards Air Force Base, CA 93523-5000

Ms. Sandra G. Hart
Ames Research Center
MS 262-3
Moffett Field, CA 94035

Commander, Letterman Army Institute
of Research
ATTN: Medical Research Library
Presidio of San Francisco, CA 94129

Mr. Frank J. Stagnaro, ME
Rush Franklin Publishing
300 Orchard City Drive
Campbell, CA 95008

Commander
U.S. Army Medical Materiel
Development Activity
Fort Detrick, Frederick, MD 21702-5009

Commander
U.S. Army Aviation Center
Directorate of Combat Developments
Building 507
Fort Rucker, AL 36362

U. S. Army Research Institute
Aviation R&D Activity
ATTN: PERI-IR
Fort Rucker, AL 36362

Commander
U.S. Army Safety Center
Fort Rucker, AL 36362

U.S. Army Aircraft Development
Test Activity
ATTN: STEBG-MP-P
Cairns Army Air Field
Fort Rucker, AL 36362

Commander U.S. Army Medical Research
and Development Command
ATTN: SGRD-PLC (COL Sedge)
Fort Detrick, Frederick, MD 21702

MAJ John Wilson
TRADOC Aviation LO
Embassy of the United States
APO New York 09777

Netherlands Army Liaison Office
Building 602
Fort Rucker, AL 36362

British Army Liaison Office
Building 602
Fort Rucker, AL 36362

Italian Army Liaison Office
Building 602
Fort Rucker, AL 36362

Directorate of Training Development
Building 502
Fort Rucker, AL 36362

Chief
USAHEL/USAAVNC Field Office
P. O. Box 716
Fort Rucker, AL 36362-5349

Commander U.S. Army Aviation Center
and Fort Rucker
ATTN: ATZQ-CG
Fort Rucker, AL 36362

Commander/President
TEXCOM Aviation Board
Cairns Army Air Field
Fort Rucker, AL 36362

MAJ Terry Newman
Canadian Army Liaison Office
Building 602
Fort Rucker, AL 36362

German Army Liaison Office
Building 602
Fort Rucker, AL 36362

LTC Patrick Laparra
French Army Liaison Office
USAAVNC (Building 602)
Fort Rucker, AL 36362-5021

Australian Army Liaison Office
Building 602
Fort Rucker, AL 36362

Dr. Garrison Rapmund
6 Burning Tree Court
Bethesda, MD 20817

Commandant Royal Air Force
Institute of Aviation Medicine
Farnborough Hampshire GU14 65Z UK

Dr. A. Kornfield, President
Biosearch Company
3016 Revere Road
Drexel Hill, PA 29026

Commander
U.S. Army Biomedical Research
and Development Laboratory
ATTN: SGRD-UBZ-I
Fort Detrick, Frederick, MD 21702

Defense Technical Information Center
Cameron Station
Alexandra, VA 22313

Commander, U.S. Army Foreign Science
and Technology Center
AIFRTA (Davis)
220 7th Street, NE
Charlottesville, VA 22901-5396

Director.
Applied Technology Laboratory
USARTL-AVSCOM
ATTN: Library, Building 401
Fort Eustis, VA 23604

U.S. Air Force Armament
Development and Test Center
Eglin Air Force Base, FL 32542

Aviation Medicine Clinic
TMC #22, SAAF
Fort Bragg, NC 28305

Commander, U.S. Army Missile
Command
Redstone Scientific Information Center
ATTN: AMSMI-RD-CS-R
/ILL Documents
Redstone Arsenal, AL 35898

U.S. Army Research and Technology
Laboratories (AVSCOM)
Propulsion Laboratory MS 302-2
NASA Lewis Research Center
Cleveland, OH 44135

Dr. H. Dix Christensen
Bio-Medical Science Building. Room 753
Post Office Box 26901
Oklahoma City, OK 73190

Col. Otto Schramm Filho
c/o Brazilian Army Commission
Office-CEBW
4632 Wisconsin Avenue NW
Washington, DC 20016

Dr. Christine Schlichting
Behavioral Sciences Department
Box 900, NAVUBASE NLON
Groton, CT 06349-5900

COL Eugene S. Channing, O.D.
Brooke Army Medical Center
ATTN: HSHE-EAH-O
Fort Sam Houston, TX 78234-6200

LTC Gaylord Lindsey (5)
USAMRDC Liaison at Academy
of Health Sciences
ATTN: HSHA-ZAC-F
Fort Sam Houston, TX 78234